

# 2005 Solar Decathlon Rules and Regulations

## Main Documents

	Number of Pages	Date of Last Revision
<a href="#"><u>Overview</u></a>	7 pages	November 2, 2004
<a href="#"><u>Definitions</u></a>	4 pages	November 2, 2004
<a href="#"><u>Regulations</u></a>	22 pages	November 2, 2004
<a href="#"><u>Contests</u></a>	3 pages	February 10, 2004
<a href="#"><u>Contest 1: Architecture</u></a>	1 page	February 10, 2004
<a href="#"><u>Contest 2: Dwelling</u></a>	2 pages	February 10, 2004
<a href="#"><u>Contest 3: Documentation</u></a>	3 pages	February 10, 2004
<a href="#"><u>Drawings and Submittals (Contest 3 Details)</u></a>	6 pages	November 2, 2004
<a href="#"><u>Schematic Energy Analysis Report (Contest 3 Details)</u></a>	1 page	November 2, 2004
<a href="#"><u>Project Summary (Contest 3 Details)</u></a>	3 pages	November 2, 2004
<a href="#"><u>Pre-Event Deliverables (Contest 3 Details)</u></a>	2 pages	November 2, 2004
<a href="#"><u>Contest 4: Communications</u></a>	3 pages	February 10, 2004
<a href="#"><u>Web Site (Contest 4 Details)</u></a>	7 pages	February 10, 2004
<a href="#"><u>Contest 5: Comfort Zone</u></a>	4 pages	February 10, 2004
<a href="#"><u>Contest 6: Appliances</u></a>	3 pages	February 10, 2004
<a href="#"><u>Cooking Task (Contest 6 Details)</u></a>	5 pages	November 2, 2004
<a href="#"><u>Contest 7: Hot Water</u></a>	2 pages	February 10, 2004
<a href="#"><u>Contest 8: Lighting</u></a>	7 pages	November 2, 2004



[Contest 9: Energy Balance](#)

1 page

February 10, 2004

[Contest 10: Getting Around](#)

1 page

February 10, 2004

## Supplemental Documents

[Battery Requirements and Guidelines](#)

15 pages

March 12, 2004

[Brief Contest Reports](#)

1 page

November 2, 2004

[Codes and Compliance Regulations](#)



13 pages

November 2, 2004

[Communications](#)

1 page

February 10, 2004

[Suggestions for Making Your Team's Solar Decathlon Web Site a Winner](#)

6 pages

February 10, 2004

[Instructions for Submitting Images \(Graphics and Photographs\)](#)

2 pages

November 2, 2004

[Guidelines for Sponsor Recognition on the National Mall](#)

3 pages

February 10, 2004

[Instrumentation and Monitoring: Design Considerations for Teams](#)

3 pages

March 12, 2004

[Pre-Event Schedule](#)

2 pages

November 2, 2004

[Solar Decathlon Accessibility Requirements and Guidelines](#)

41 pages

March 12, 2004

## Overview

*The Engineer's aesthetic, and Architecture, are two things that march together and follow one from the other.... The Engineer, inspired by the law of economy and governed by mathematical calculation, puts us in accord with universal law. He achieves harmony. The Architect, by his arrangement of forms, realizes an order, which is a pure creation of his spirit...it is then that we experience the sense of beauty. —Le Corbusier*

The Solar Decathlon is an intercollegiate and interdisciplinary design and construction competition that takes up a persistent and age-old question: How do we integrate architecture and technology with a dwelling? In other words, what makes a good house?

More than 2,000 years ago, the Roman architect Vitruvius claimed that all buildings should possess the qualities of “firmness, commodity, and delight.” Centuries later, architects and engineers of the Industrial Revolution were inspired and challenged by the new technologies and building tasks their age presented. In the early twentieth century, the influential Swiss Modernist architect, Le Corbusier, wrote in *Towards a New Architecture*, “Let us state the problem. Let us shut our eyes to what exists. A house: a shelter against heat, cold, rain, thieves, and the inquisitive. A receptacle for light and sun. A certain number of cells appropriate to cooking, work, and personal life.”

The sources of energy that powered the Industrial Age have revealed their limitations and their consequences, as contemporary living demands more and more energy for “commodity and delight” as well as “cooking, work, and personal life.” Architecture and engineering students of today, then, face both an old and a new problem: to satisfy an age-old curiosity about dwelling while solving the relatively new problem of post-industrial energy and its consequences. The Solar Decathlon challenges engineering and architecture students to design and construct a fully self-sufficient solar-powered house. Or, to paraphrase and gather inspiration from Le Corbusier’s words: a sun-machine for living in.

Like the athletic decathlon, the Solar Decathlon will test proficiency in a wide range of skills. Unlike its athletic counterpart, however, the Solar Decathlon is a team event, in which the diversity of abilities comes from the composition of the team rather than a single individual. Architecture and engineering students will work with students from other disciplines such as marketing, communications, graphic design, analysis, and computer science to do the troubleshooting, communicating, dreaming, and building this challenging project requires.

The second Solar Decathlon will take place on the National Mall in Washington, D.C., in the fall of 2005. For approximately three weeks, the Solar Decathlon organizers and teams will assemble and inhabit a “Solar Village” in view of the Nation’s capitol. When the village is fully assembled, teams will compete against each other during a week of 10 decathlon contests. The team with the highest point total at the end of the week will be the winner. Additional awards will be presented in several other categories. The village also will be open to the public and media, who will be invited to tour the teams’ homes and the educational exhibits provided by the organizers and sponsors.

The 10 contests are based on three guiding principles for the competition:

- The teams must supply the energy requirements necessary to live and work using only the sunlight shining on their entry—the global solar radiation incident on the house, specifically—during the contests.
- The houses will exemplify good design principles that will increase the public’s awareness of the aesthetic and energy benefits of solar and energy efficiency design strategies and technologies, which in turn will increase the use of these design principles and technologies.
- The work of the teams, organizers, and sponsors will stimulate accelerated research and development of renewable energy, particularly in the area of building applications.

The following set of priorities determines what the 10 contests should encompass.

- **Energy Production:** Each team’s house must be able to supply all of the energy needed for its occupants to survive and prosper in today’s society. Within their comfortable and well-lit houses, the teams will perform domestic tasks that require the operation of appliances and electronics, and they will transport themselves around town in an electric vehicle—all of this with energy from only the solar electric and solar thermal systems integrated into their houses. The competition will quantify each team’s energy production and productive output.
- **Energy Efficiency:** Efficiency reduces consumption and enables more work to be accomplished with a given amount of energy. Because the amount of sunlight that strikes the surface of a house is limited, end-use efficiency will be a key strategy to success.
- **Design:** Since the time of Vitruvius, design has been an essential part of deciding what makes “a good house.” Good design improves structural integrity (“firmness”), function and comfort (“commodity”), and aesthetic appeal (“delight”). Whether a house is a “good house” may be qualified by the architect who designs it, the engineer who optimizes its performance, the builder who constructs it, and the occupant who lives and works in it. Good design becomes more challenging as the building industry strives to integrate existing ideas and technologies with an increasing array of new ideas and technologies, many of which are just being introduced. Design is a critical part of the Solar Decathlon, emphasizing overall dwelling livability and structural and systems aesthetics and integration, especially integration of the dwelling with its energy systems.
- **Project Documentation:** Good design is as much a process as it is the result evidenced in the finished house. The competition requires teams to demonstrate their design processes by providing documentation such as energy performance analyses, drawings, and design narratives at the schematic design, design development, and “as-built” phases of their projects.

- ***Communications:*** Effective communications save time and improve our safety and quality of life by supplying the important information we use to make critical decisions. Variety, content, and design are essential to drawing an audience to a message. Getting a clear message about delightful design, energy efficiency, and solar energy to the public audience will be an important consideration in this competition.
- ***Heating and Air Conditioning:*** As Le Corbusier stated, a house must be a comfortable space in which to live, protected from wind and rain, from winter's snow, and summer's heat. For good health, the conditioned space must also minimize indoor pollutants. To succeed, the teams' houses must provide interior comfort and good environmental quality while meeting the energy requirements of the competition.
- ***Appliances and Electronics:*** Household appliances and electronics have improved our quality of life since the dawning of the industrial age. They use energy to save the physical energy and time of a household's inhabitants, and they provide entertainment and access to global communications. The demand for appliances and electronics grows greater every day, even as the consequences of supplying the energy they require becomes ever more apparent. The Solar Decathlon will challenge students to meet the energy demands of domestic and working life while competing to solve the problem of the consequences of energy use in the post-industrial age.
- ***Hot Water:*** Hot running water is considered a necessity. Energy- and water-saving strategies and technologies are readily available. The competition challenges the teams to demonstrate these options while meeting average hot water requirements for domestic activities.
- ***Lighting:*** Lighting improves our safety, productivity, and quality of life. Beyond its purely practical application, lighting also has the power to please the inhabitants of the "receptacle for light" that Le Corbusier described. The Solar Decathlon requires teams to design lighting solutions that are energy-efficient and abundant, as well as pleasing to the houses' inhabitants.
- ***Transportation:*** Mechanized transportation gives us greater freedom, saves time, and improves productivity. The competition will reward teams that can plan their use of transportation the most efficiently and that use their houses' energy systems to provide the energy to meet their transportation needs.

## Team Selection

The Solar Decathlon is an international competition open to all accredited colleges, universities, and other post-secondary educational institutions. Entrants are selected through a proposal process. All proposals are reviewed, scored, and ranked. Depending on the quantity and quality of submissions, a limited number of teams from all entries are selected for entry.

For the 2005 Solar Decathlon, the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) issued a Request for Proposals in February 2003. Proposals were due in April 2003. After reviewing, scoring, and ranking the proposals, a team of reviewers from DOE and NREL selected the following teams to compete in 2005:

- California Polytechnic State University, San Luis Obispo
- Carnegie Mellon, University of Pittsburgh, and the Art Institute of Pittsburgh
- Concordia University
- Cornell University
- Crowder College
- Florida International University
- New York Institute of Technology
- Rhode Island School of Design
- Universidad Politécnica de Madrid
- University of Colorado at Denver and Boulder
- University of Maryland
- University of Massachusetts Dartmouth
- University of Michigan
- University of Missouri—Rolla and the Rolla Technical Institute
- University of Puerto Rico, Mayagüez
- University of Southern California
- University of Texas at Austin
- Virginia Polytechnic Institute and State University
- Washington State University

Representatives from each of the teams attended a kick-off workshop in Washington, D.C., in September 2003. The workshop included information sessions about the competition and presentations from experts in the fields of architecture, building energy efficiency, fund raising, and communications.

## The 10 Contests

The Solar Decathlon organizers have selected the following 10 contests for the 2005 competition. The teams can earn up to 100 points for each contest except Architecture, for which they can earn up to 200 points. Of the 1100 total points possible, 480 points are awarded based on objective performance measurements or task completion, and 620 points are awarded through subjective evaluations by a variety of appropriately selected experts. For details about scoring: [Contests](#).

### ***Contest 1: Architecture***

To be architecturally sound, a home's design must not only satisfy human comfort needs, it must also be well organized and visually pleasing both inside and out. The Architecture contest is designed to demonstrate that solar-powered, energy-efficient homes can be designed to meet enduring architectural standards. Although the technologies in these competition houses are relatively new, the classic architectural standards of "firmness, commodity, and delight" remain the criteria for a successful building. A jury of architects will judge each entry on the overall aesthetics and the successful design and integration of the solar, energy-efficiency, and other technical features of the house. The jury will evaluate the houses early in the week of contests and will not be influenced by the objectively measured performances of the houses. For more details about: [Contest 1: Architecture](#).

### ***Contest 2: Dwelling***

An important objective of the Solar Decathlon is to prove that solar and energy-efficient design and technologies are market ready and belong in the world's diverse neighborhoods today. The Dwelling contest begins, in a sense, where the Architecture contest ends: after the design and construction of the houses are complete and living in them begins. Experts from the building industry (e.g., builders, marketing and design professionals) and representative homeowners will comprise the judging panel for this contest. Judging will take place early in the week of contests and will not be influenced by the objectively measured technical performance of the houses. For more details about: [Contest 2: Dwelling](#).

### ***Contest 3: Documentation***

Good design emerges from a process of exploring and evaluating alternatives through drawings, physical and computer-based models, and analyses. The Documentation contest evaluates the production of an imaginative and thorough set of documents from the schematic design, design development, construction, and "as-built" phases of the Solar Decathlon project. Analyses in the schematic design phase will focus primarily on energy performance. Documents illustrating the construction of the building are required at the design development, construction, and as-built phases. A panel of experts in building energy simulation will judge the energy analyses, and a panel of engineers and the architectural jury will evaluate the as-built drawings. Some evaluations for this contest will take place as the teams' projects develop before fall 2005. The evaluations that occur in fall 2005 will take place early in the week of the contests and will not be influenced by the objectively measured technical performance of the houses. For more details about: [Contest 3: Documentation](#).

### ***Contest 4: Communications***

The Solar Decathlon is a competition and a public event. The Communications contest challenges teams to communicate their experiences in this project to a general audience. Through Web sites and public tours, the teams will share the knowledge they have acquired. Their experiences and their houses will serve as living demonstrations of the viability of solar energy and energy efficiency technologies in the home. Panels of judges with expertise in communications and public relations will award points based on subjective evaluations of the teams' Web sites, house tours, and overall "branding effectiveness" (the ability to deliver clear and consistent messages and images that represent the teams' missions, visions, goals, and results). For more details about: [Contest 4: Communications](#).

### ***Contest 5: Comfort Zone***

Well-designed houses provide interior comfort and indoor environmental and air quality through heating, cooling, and humidity controls and ventilation. For this contest the teams will be evaluated objectively on their ability to maintain temperature and relative humidity within prescribed set points. A panel of heating, ventilating, and air conditioning experts will award points for the quality of thermal comfort and good indoor environmental and air quality based on subjective evaluations of each house. For more details about: [Contest 5: Comfort Zone](#).

### ***Contest 6: Appliances***

A house is not a home without kitchen appliances, laundry facilities, and electronics such as personal computers and TV/video players. This contest requires the teams to demonstrate that their houses can provide the necessary energy to effectively operate appliances and electronics. The teams will store food in their refrigerators and freezers, cook a set number of meals, wash dishes, and do laundry during the week of contests. The teams will also be required to operate their personal computers and TV/video players a set number of hours each day. All points for this contest will be awarded based on task completion and objective performance evaluations of the required appliances and electronics. For more details about: [Contest 6: Appliances](#).

### ***Contest 7: Hot Water***

This contest demonstrates that the teams' houses can provide all of the energy necessary to heat water for domestic uses. Teams will receive points for performing tests that simulate the average time and temperature requirements for two showers each day of the contest week. Twice per day, teams will have to deliver 15 gallons (56.8 liters) of hot water [at least 110°F (43.3°C)] in no more than 10 minutes. A panel of engineers will also award points based on subjective evaluations of the overall design of the teams' hot water systems. For more details about: [Contest 7: Hot Water](#).



### ***Contest 8: Lighting***

Sunlight, moonlight, and electric light all contribute to the livability and environment of a dwelling, inside and out. Lighting systems should be designed to minimize energy use by maximizing the contribution of daylighting and by using controls to minimize the use of electric illumination. This contest evaluates the quantity and quality of the lighting in the houses both day and night. Points will be awarded on a team's ability to provide lighting levels within prescribed set points. These lighting levels will be measured objectively. A panel of lighting designers will award points on the basis of subjective evaluations of the teams' lighting system designs. For more details about: [Contest 8: Lighting](#).

### ***Contest 9: Energy Balance***

This contest demonstrates that the sun can supply the energy necessary for all the daily energy demands of a small household and home-based business. The object is to begin and end the contests with the same amount of energy stored in the electrical storage system to demonstrate that the system functions sustainably. Points will be awarded based on each team's ability to use their solar electric systems to produce as much electrical energy as they require during the contest week. For more details about: [Contest 9: Energy Balance](#).

### ***Contest 10: Getting Around***

Because the amount of energy households use to meet their personal transportation needs is so significant, this contest is designed to demonstrate that a house itself can be used to provide that energy. The contest evaluates how much "extra" energy the houses can generate to provide transportation for the teams in street-legal, commercially available electric vehicles, which will be provided by the organizers. Teams will be required to log miles each day of the contest week as they "run errands" just the way we do in our everyday lives. All points for this contest will be awarded based on objective evaluation—the more miles the teams drive, the more points they get. For more details about: [Contest 10: Getting Around](#).

#### **Summary of Revisions**

November 2, 2004

- Minor editorial changes.

## Definitions

*Architecture Jury*—The group of individuals selected by the Organizers to carry out the Architecture Jury Evaluation Contest Activity.

*Assembly*—Activities of the Teams and Organizers that have to do with assembling and installing the Solar Decathlon Solar Village on the National Mall for the Event and Competition.

*Chief Observer*—The individual selected by the Organizers to direct and oversee the activities of the Observers.

*Competition*— All aspects of the Solar Decathlon that relate to the 10 Contests and the scoring of those Contests.

*Construction*—The Teams' activities that have to do with constructing their Solar Decathlon houses (all of the components) on the teams' original sites (e.g., their campuses) before the houses are transported to the National Mall for the Event and Competition.

*Contest*—One of the 10 categories in which teams will be evaluated against each other to determine a winner of the Competition.

*Contest Activity*—An individually scored component within a Contest. Some Contests consist of only one Contest Activity; other Contests consist of multiple Contest Activities.

*Contest Officials*—Individuals appointed by the Organizers to monitor specific Contest Activities. Contest Officials are responsible (1) for interpreting the Rules and Regulations specific to the Contest(s) that they have been appointed to officiate and (2) for identifying any infractions of the Rules and Regulations that relate to those Contest(s).

*Contest Week*—The period of approximately 7 to 9 days on the National Mall when some or all Contests are active.

*Decathlete*—A registered, student team member allowed to participate in Contest Activities during the Contest Week.

*Director*—The individual with the ultimate decision-making authority regarding all aspects of the Project.

*Disassembly*—Activities of the Teams and Organizers that have to do with the expeditious removal of everything (e.g., structures, equipment, tools, vehicles, trash, and debris) from the National Mall after completion of the Event and Competition.

*Event*— The series of activities that take place at the Event site (in Washington, D.C., and on the National Mall). Activities include, but are not limited to, registration, Assembly, inspection, Competition, special events, hours of public access, and Disassembly.

*Event Sponsor*—An entity identified by the Organizers that supports the overall Solar Decathlon. The U.S. Department of Energy (DOE) is the primary sponsor of the Solar Decathlon. DOE partners with other institutions—such as its National Renewable Energy Laboratory (NREL), the American Institute of Architects, and The Home Depot—in support of the Project.

*Event Staff*—A team of individuals selected by the Organizers to conduct Event activities that include, but are not limited to, registration; safety; village infrastructure, logistics, and Assembly; inspections; instrumentation and monitoring; special events; communications and public outreach; media relations; Contest evaluations; and Disassembly.

*Faculty Advisor*—An individual team member who is a faculty member from one of the institutions (i.e., school, college, or university) selected for participation in the Project. The Faculty Advisor provides guidance to the team on an as-needed basis throughout the Project and obtains appropriate signatures on documents that require the institution's or institutions' concurrence or authorization.

*Headquarters*—During the Event, a Headquarters established at the Event site houses administrative and management functions for the Event.

*Inspectors*—The individuals selected by the Organizers to visit teams for pre-Event inspections (at the teams' Construction sites), and the individuals responsible for inspections during the Event. They conduct inspections to ensure compliance with Solar Decathlon Rules and Regulations.

*Judge*—Individual selected by the Organizers to judge and score all Contest Activities (except Contest 1: Architecture) of a subjective nature.

*Juror*—Individual selected by the Organizers to serve on the Architecture Jury.

*Observer*—A person who is assigned to each team by the Chief Observer to observe team activities during the Competition. The Observer reports to the Chief Observer any observed violation of the Rules and Regulations but does not provide an official interpretation of the Rules and Regulations. The Observer also verifies that tasks are completed.

*Official Scores*—The final scores provided by the Scoring Official at the end of the Competition.

*Organizers*—The body of individuals selected by the Director and Project Manager to be responsible for organizing the Project. The Organizers select Contest Officials, the Scoring Official, Inspectors, Judges, Jurors, Observers, the Rules and Regulations Committee, the Protest Resolution Committee, and Event Staff.

*Panel of Judges*—One of several groups of judges selected by the Organizers to evaluate and score all Contest Activities (except Contest 1: Architecture) of a subjective nature.

*Project*—All activities involved in the Solar Decathlon from the initial meetings through the conclusion of the Event.

*Project Manager*—The individual who manages all aspects of the Project, including (but not limited to) such personnel as the Organizers, Rules and Regulations Committee, Inspectors, Judges, Jurors, and Event Staff.

*Protest Resolution Committee*—The group of individuals selected by the Organizers to resolve appropriate team protests during the Competition.

*Protest Resolution Committee Chair*—The individual selected by the Organizers to oversee the activities of the Protest Resolution Committee.

*Rules and Regulations*—This document and any requirements, procedures, permissions, and guidelines that govern the Solar Decathlon Project.

*Rules and Regulations Committee*—The group of individuals selected by the Organizers to be responsible for writing and revising this Rules and Regulations document and its amendments. The Rules and Regulations Committee is also responsible for writing or providing (or both) supplemental documents to the Rules and Regulations.

*Rules and Regulations Committee Chair*—The individual selected by the Organizers to be responsible for overseeing the activities of the Rules and Regulations Committee.

*Scoring Official*—The individual selected by the Organizers to be responsible for unofficial and official scores.

*Team Member*—An individual student, faculty member, or other employee from one of the institutions (i.e., school, college, or university) selected to participate in the Project.

*Team Sponsor*—An entity identified by a team that supports the team's participation in the Solar Decathlon.

*Unofficial Scores*—All scores published before Official Scores are published, which occurs at the end of the Competition.

## Summary of Revisions

November 2, 2004

- Changed Contest Week to 7 to 9 days (previously 5 to 7 days).

# Regulations

## 1. Administration

### *1.1 Rules and Regulations Authority*

The Solar Decathlon Rules and Regulations are issued under the authority of the Rules and Regulations Committee. Official printed or electronic communications from the Rules and Regulations Committee and/or Organizers shall be considered part of, and shall have the same validity as these Rules and Regulations. If there is a conflict between official printed or electronic communications and these Rules and Regulations, the information having the later date shall take precedence. Official communications will be made available to the teams via one or more of the venues indicated in Section 2, Official Communications.

If there is any doubt or ambiguity as to the wording or intent of these Rules and Regulations, the decision of the Rules and Regulations Committee shall prevail. Infractions of these rules can lead to warnings, point penalties and, in extreme cases, disqualification. Safety and good sportsmanship will not be compromised.

### *1.2 Effective Date of Rules and Regulations*

The Rules and Regulations posted on the Solar Decathlon Web site and dated for the year of the Event are the Rules and Regulations in effect. Rules and Regulations dated for other years are invalid.

### *1.3 Violations of Intent*

A violation of the intent of a rule or regulation will be considered a violation of the rule or regulation itself. Questions about the intent of a rule or regulation may be addressed to the Rules and Regulations Committee per the instructions in Section 2: Official Communications.

### *1.4 Rules and Regulations Compliance*

By entering a Solar Decathlon Project, the team, faculty advisor, and the members of the team as individuals agree to comply with, and be bound by, these Rules and Regulations and any procedures announced by the Organizers.

## 1.5 Organizer Authority

The Organizers of the competition reserve the exclusive right to revise the schedule of the Project and to interpret or modify (or both) the Rules and Regulations at any time and in any manner that is, in their sole judgment, required for the efficient operation or safety of the competition.

## 2. Official Communications

It is the teams' responsibility to stay current with official communications regarding the Project. Official communication between the teams and the Director, Project Manager, Organizers, Rules and Regulations Committee and Chair, Headquarters, Inspectors, Event Staff, Contest Officials, Chief Observer, Scoring Official, Protest Resolution Committee Chair, and any other Solar Decathlon staff and officials will occur through, but not be limited to, one or all of the following. (Teams will be notified of any changes in methods or venues for official communications.)

- *Solar Decathlon Yahoo! Group also known as "the Group"*: All official communication suitable for viewing by all teams will be posted on the Yahoo! Group (open to teams and Organizers only) (<http://groups.yahoo.com/group/solardecathlon/>). The Group includes a section for posting files. If files are too large, they will be posted on the Solar Decathlon ftp site or Web site, and the teams will be notified via the Group as to where they can locate the files. Teams must follow the Organizers' instructions (provided to each team in September 2003) to join the Group. The Group will be the primary venue for official communications, so the teams should check the Group often for new information.
- *Rules and Regulations Committee Chair Email*: For confidential inquiries regarding the Project, teams should email the Rules and Regulations Committee Chair ([sdrules@nrel.gov](mailto:sdrules@nrel.gov)). The Chair will route these inquiries appropriately, and the inquiries will be kept confidential.
- *Solar Decathlon ftp site*: The ftp site ([ftp://ftp.nrel.gov/pub/solar\\_decathlon/](ftp://ftp.nrel.gov/pub/solar_decathlon/)) will be used by the Organizers to make large files available to the teams. The Organizers may also request that the teams use the ftp site to make large files available to the Organizers. Notification of or requests for file transfers will be made via the Yahoo! Group or email.
- *Solar Decathlon Web site*: Space on the Yahoo! Group is limited. Files of a more permanent nature (e.g., the official Rules and Regulations) will be made available via the Solar Decathlon Web site (<http://www.solardecathlon.org/>). Notification of new or updated information on the Web site will be provided via the Group.
- *Conference calls*: The teams will be invited to participate in periodic informational sessions via conference calls. Invitations and instructions for participation in conference calls will be provided via the Group.
- *Meetings*: Before the Event, the teams and Organizers will have two meetings: a kick-off meeting in September 2003, and a meeting concurrent with the IEEE PV Specialists Conference in January 2005. During the Event, a meeting will be held the day before assembly begins on the Mall, and meetings will be held daily on the Mall throughout the Event.

- *Postings at Headquarters:* During the Event, a bulletin board (or other obvious venue for posting information) may be established at Headquarters. Teams will be notified via the Group or email if such a venue is established and the purpose for which it has been established.
- *Email:* For expediency and to protect confidentiality, the Organizers may choose to communicate with teams via the team email addresses provided to the Group. However, the bulk of official communication will occur via the Group and the Web site.

### **3. Communications Materials**

Communications materials refer to all content, graphics, and photographs that appear in any submissions to the Organizers and to any products (print, electronic, video or film, and merchandise) for fund-raising, marketing, advertising, educational, promotional, publicity, team identification, and public outreach purposes.

#### ***3.1 Organizer and Event-Sponsor Use of Likeness, Content, and Images***

By entering the Project, Event, and Competition, all teams, Team Members, contractors, and volunteers agree to the use of their names and their likenesses in any communications materials that may be issued by the Organizers or Event Sponsors. By entering the Project, Event, and Competition, all teams and Team Members agree to the use of any content, graphics, and photos from any communications materials that they produce for the Project in any communications materials produced by the Organizers or Event Sponsors. Content and images (graphics and photos) may be made available to the general public via the U.S. Department of Energy's, the National Renewable Energy Laboratory's, and the Event Sponsors' Web sites with unrestricted use. Images and content, and any publications in which the images and content appear, may be viewable without restrictions on the Internet. Before August 9, 2005, if the teams submit content or images they would like to be kept confidential, they should make that request, with an explanation, in writing to the requestor of the content or images. For example, if a team would like to keep specific content or images in the design development drawings and submittals confidential, they should note that in a cover letter with the submission. Every effort will be made to honor requests for confidentiality. The Organizers and Event Sponsors will make all reasonable efforts to credit the sources of content and images, although they may be published without credit. To ensure proper usage of and credit for images, teams should submit photos and graphics by following the [Instructions for Submitting Images](#).

#### ***3.2 Event-Sponsor Recognition***

All communications materials produced by the teams or Team Sponsors concerning or referring to the Project will refer prominently to the Project as the Solar Decathlon. All communications materials produced by the teams will credit the U.S. Department of Energy, the National Renewable Energy Laboratory, and additional Event Sponsors as indicated by the Organizers. The Solar Decathlon will be recognized with text and logo wherever other logos are used. Information regarding current Event Sponsors, artwork for the Solar Decathlon, and Event Sponsor logos will be available on the Solar Decathlon Web site (<http://www.solardecathlon.org/>).



### **3.3     *Communications Materials on the National Mall***

All communications materials to be present or distributed on the National Mall will follow the [Guidelines for Sponsor Recognition on the National Mall](#). The National Park Service (NPS) is very concerned about the amount of printed material distributed on the National Mall. Teams are limited to one media/VIP kit and one brochure. The contents of the media/VIP kit must be in a binder or folder; they will be available to the media and visiting VIPs but are not to be distributed to the general public. Teams are limited to one brochure for distribution to the visiting public.

### **3.4     *Team Uniforms***

The only information or graphics that are approved to be visible from the front of the team uniform (jacket, shirt, hat, or other wearable item) shall be the institution and its logo, the team name and logo, the Solar Decathlon logo and Event Sponsor logos as indicated on the Solar Decathlon Web site (<http://www.solardecathlon.org/>). Team Sponsor logos are to be visible only from the back of the team uniform shirt or jacket.

## **4.     *Safety/Insurance***

Each team is responsible for the safety of its house, vehicles, and Team Members, and for obtaining all necessary insurance. Passing inspection or implementing changes suggested by the Director, Project Manager, Organizers, Rules and Regulations Committee, Event Staff or any other person associated with the Solar Decathlon does not release the teams from liability. Team members must behave in a safe manner at all times. All houses, vehicles, equipment, and tools must be maintained and operated safely at all times. A team may be disqualified and withdrawn from the Project at any time if they behave or operate their house, vehicles, equipment, or tools in an unsafe manner. Organizers and Event Staff may issue a stop work order at any time during the Project if they perceive any safety violation. The Director or Project Manager (or both) will make the final determination as to the severity of and penalty for (up to disqualification) a safety violation.

Each team's house must be equipped with proper personal protective equipment (PPE) to provide to all of its workers during the Event. At a minimum, teams must provide an adequate amount of hard hats; climbing harnesses; ear plugs; eye protection; work gloves; work boots; chemical-resistant gloves, aprons and eye protection for servicing battery banks; and protection from any other thermal, electrical, mechanical or fluid system that presents any kind of hazard.

## **5. Conduct**

Penalties, including disqualification from the Project, Event, and Competition may be imposed for improper conduct or for the use of alcohol or illegal substances. Improper conduct may include but is not limited to improper language, unsportsmanlike conduct, unsafe behavior, distribution of inappropriate media, or cheating. See Regulation 6, Penalties, about the process for qualifying, quantifying, and assessing penalties and for more information about disqualification.

## **6. Penalties**

Any team failing to comply with these Rules and Regulations during the Project will be penalized. Penalties range from official warnings to point penalties to disqualification from the Project, Event, or Competition. During the Project, it is the Project Manager's responsibility (in consultation with Contest Officials, Event Staff, Judges, Jurors, Inspectors, Observers, Organizers, or the Rules and Regulations Committee, depending on the nature of the infraction) to determine whether an infraction has occurred. If an infraction has occurred, the Project Manager shall qualify the severity of the incident and quantify the appropriate penalty. The Project Manager will submit all point penalties to Solar Decathlon Headquarters for posting. The Scoring Official will assess and post all penalties before the announcement of official scores. Disqualification of a team from the Project requires prior notice to the team, an opportunity for the team to make an oral or written statement on its own behalf, and, finally, the concurrence of the Director.

## **7. Protests**

Any team desiring to file a protest must do so by submitting an official written protest (signed by the team leader) to Solar Decathlon Headquarters within the time stipulated in Regulation 7.2, Time Limit. Protests may be filed for any reason, including disputing a penalty levied against any team, correcting point errors, or protesting the actions of another team. A "filing fee" of 10 points, which could be refundable, will be assessed against the team's Official Score. The Protest Resolution Committee Chair (in consultation with Contest Officials, Event Staff, Judges, Jurors, Inspectors, Observers, Organizers, or the Rules and Regulations Committee, depending on the nature of the protest) will evaluate the appropriateness of all team protests to determine which protests the Protest Resolution Committee should review. The decision will be based on the documentation submitted. No appearance is authorized. No right to counsel is authorized.

### ***7.1 Protest Decisions***

The decision of the Protest Resolution Committee is final, and no further appeals are allowed. The Protest Resolution Committee Chair will notify Solar Decathlon Headquarters of its decision, and Headquarters then will inform the affected teams. Based on its assessment and decision, the Protest Resolution Committee may refund some of or the entire filing fee to the filing team's score.

## **7.2     *Time Limit***

Except for the last day of the Contest Week, all protests must be filed within 24 hours of the action being protested. The latest possible time for filing protests is 7:00 p.m. on the last day of the Contest Week.

## **8.     Team Requirements**

### **8.1     *Entry***

The Project is open to colleges, universities, and other post-secondary educational institutions. Entry is determined through a proposal process. All proposals will be reviewed, scored, and ranked. Subject to the quantity and quality of submissions, a limited number of teams, out of the total number of institutions that submitted proposals, will be selected for entry.

### **8.2     *Faculty Advisor***

Teams must have at least one Faculty Advisor who will provide guidance on an as-needed basis throughout the Project. The Faculty Advisor will be responsible for obtaining appropriate signatures on documents that require the school's or schools' concurrence or authorization.

### **8.3     *Registration***

All Team Members taking part in the Event must register. On-line registration and on-site (in Washington, D.C., and on the Mall) registration will be available for Team Members. Team Members are encouraged to register on-line, because on-site registration could cause delays in their access to their team's site on the Mall. When they register, Team Members must complete all required information and forms, and provide a photo for a photo ID badge. These badges are required for all access to the entire site on the Mall during certain times and to certain restricted areas. Badges must be visible at all times. Team contractors, volunteers, and visitors must register on site and complete all required information and forms. In some cases, team contractors, volunteers, and visitors may be issued a photo ID badge. Each participant (Team Members, contractors, volunteers, and visitors) must register individually; no group registration will be allowed. Visiting media must check in with Headquarters.

#### **8.4     *Decathletes***

Only registered Decathletes will be allowed to compete in the 10 Contests and participate in Contest Activities. During the Contest Week, a team shall have a maximum of six Decathletes operating the house and two decathletes operating the car at one time. The same eight individuals do not have to remain Decathletes for the entire Contest Week. Decathlete status is transferable to other student Team Members. Teams will be allotted eight Decathlete badges for tracking purposes. In addition to meeting the Decathlete requirements, car drivers and passengers must be 18 years old or older and present a valid driver's license and evidence of insurance. The Faculty Advisor and any other non-student Team Members may not be Decathletes.

#### **8.5     *Team Members***

Only post-secondary students (including current students or students who have graduated within 12 months of the Event) and faculty from the institutions selected by the Organizers to participate in the Project can be Team Members. However, teams are encouraged to seek assistance from experts in industry, research, and academia.

#### **8.6     *Uniforms***

During the Competition from 7:00 a.m. to 10:00 p.m., and during special events specified by the Organizers or Event Staff, all Team Members present on the National Mall or the site of a specified special event shall wear uniforms representing their institution(s) (i.e., school, college, or university).

#### **8.7     *House Transport, Assembly, and Disassembly***

Teams shall be responsible for the transport of their houses, the houses' contents, electric vehicles, and all equipment and tools necessary for the Event and shall be responsible for any damage to or loss of such items. Teams are responsible for procuring any equipment, tools, and supplies at the Event.

#### **8.8     *Travel, Accommodations, and Lodging***

All teams are responsible for their team's transportation, accommodations, lodging, food and beverages (including drinking water) during the Event. Teams are responsible for making their own reservations and arrangements and for covering all necessary costs.

## **8.9     *Withdrawals***

Any team wishing to withdraw must notify, in writing, the Project Manager (before the Event) or Headquarters (during the Event). All written withdrawals signed by the team leader are final. The Project Manager or Headquarters may disqualify teams that do not meet Project requirements or that fail inspections during either the Project or Event. Any disqualification decision shall be in writing and, once presented to the team, the decision shall be final.

## **8.10   *Vehicular and General Liability Insurance***

The school, at the school's expense, shall maintain, for the duration of the Event, vehicular liability insurance with limits of liability for bodily injury of not less than US \$200,000.00 for each person and US \$500,000.00 for each occurrence; and limits of liability for property damage of not less than US \$40,000.00 for each accident and US \$500,000.00 for each occurrence.

The school, at the school's expense, shall maintain, for the duration of the Event, general liability insurance with limits of liability for bodily injury of not less than US \$500,000.00 for each person and US \$500,000.00 for each occurrence; and limits of liability for property damage of not less than US \$100,000.00.

The school, at the school's expense, shall maintain, for the duration of the Event, workers compensation insurance for non-volunteering employees of the school present at the Event with limits of liability as required by applicable law, and employer's liability insurance for liability for bodily injury of not less than US \$100,000.00 for each person and US \$100,000.00 for each occurrence.

The school agrees to furnish the National Renewable Energy Laboratory (NREL) or the U.S. Department of Energy (DOE), upon request, evidence satisfactory to NREL or DOE of such vehicular liability, general liability, workers compensation liability, or employer's liability insurance coverage.

## **9.     **Impound****

All houses and cars must be impounded every night of the Contests from 10 p.m. to 7 a.m. under the direct supervision of official Solar Decathlon personnel. No Team Members are allowed to occupy, move, or conduct maintenance on any part of the house or car during impound hours.

## **10. Technical**

### ***10.1 Americans with Disabilities Act (ADA)***

The public will have access to all the structures within the Solar Decathlon village at various times during the Event; therefore, all structures must meet [\*Solar Decathlon Accessibility Requirements and Guidelines\*](#). Teams are required to provide an accessible route through their houses for tour purposes. This does not mean that the entire house needs to be ADA compliant.

### ***10.2 National Park Service Regulations***

The National Park Service (NPS), the government agency that manages the National Mall, has established criteria that must be met by all teams building houses on the National Mall. Each team is financially responsible for any damage it causes to the National Mall.

#### ***10.2.1. Site Regulations***

On the grassy areas, teams will be permitted to use a forklift or similar small lifting equipment to aid in the Assembly of their houses. However, forklifts or other small vehicles used during Assembly may be driven on the grass portion of the National Mall only if these vehicles are driven on a plywood path (to protect the grass). Truck-mounted cranes, trailers, semi-trailer trucks, etc., are limited to the gravel paths and may not be driven on the grass at any time. NPS may permit trailers and semi-trailers to be driven on the grass portion if the vehicles are driven on a plywood path. Cinder block or similar pylons must support structures on the grass portion of the National Mall. Teams will not be permitted to build or place floors directly on the grass. The individual teams must provide all equipment, tools, and labor necessary to construct the house.

#### ***10.2.2. P.E. Stamp Requirement***

The NPS requires that engineering drawings be stamped by a Professional Engineer (PE) certifying that the structures are safe for the public to enter.

### ***10.3 Codes and Compliance***

Houses must comply with applicable sections of the following codes:

- 2003 International Residential Code (IRC2003)
  - Sections from the other 2003 International Codes may be applicable when an issue is not addressed by IRC 2003 or when IRC 2003 references one of the other Codes.

- The final chapter in each of the 2003 International Codes is titled “Referenced Standards.” In some rare cases, teams may have to refer to these standards. They are often available in university libraries.
- 2002 National Electrical Code (NEC2002)

Houses also must comply with the following documents created by the Organizers:

- [\*Solar Decathlon Accessibility Requirements and Guidelines\*](#)
- [\*Battery Requirements and Guidelines\*](#)

Each of the following Regulations describes requirements created specifically for the Solar Decathlon or requirements needing further elaboration:

### *10.3.1. Fire Prevention*

Each house will be required to have smoke detectors per IRC2003 requirements and a fire extinguisher with a minimum Underwriters Laboratory (UL) rating of 2A-10BC. All battery system rooms or rooms containing a battery system enclosure must have a smoke detector that is either audible from outside the room or has a remote indicator that shall be monitored by the team.

### *10.3.2. Electrical*

All houses must meet all applicable electrical requirements stated in NEC2002. Particular attention should be paid to Articles 690, 480, 445, 250, 310, 400, and 240, which refer to photovoltaic system design, storage batteries, generators, grounding, conductors for general wiring, flexible cords and cables, and overcurrent protection devices, respectively. Teams are also encouraged to read the following publication: Wiles, John C. (2001). *Photovoltaic Power Systems and the National Electric Code: Suggested Practices*, Sandia Report SAND2001-0674.

For detailed requirements specifically related to batteries, refer to the supplemental document, [\*Battery Requirements and Guidelines\*](#).

### *10.3.3. Structural*

The structural drawings and calculations included in the Construction Drawings and Submittals set must be stamped by a licensed professional engineer (PE). Obtaining the PE stamp is the responsibility of the teams, not the Organizers. The stamped structural drawings and calculations will be submitted by the organizers to the National Park Service for final approval. It is strongly recommended that teams involve a licensed structural engineer throughout the design process, because he or she could require structural design changes that could affect other aspects of the house. In addition to meeting applicable IRC2003 requirements, special attention must be given to the structural design challenges unique to the Solar Decathlon. These challenges include, but are not limited to, the following:

- Increased live loads because of the house tours
- Necessity for tie-downs because of the lack of a permanent foundation (tie-downs must not penetrate more than 18 in. (45.7 cm) into the National Mall topsoil)
- Use of low-impact footings to protect the National Mall grass
- Unique wind loading conditions because of roof-mounted solar systems
- Increased dead loads because of unusual mechanical and electrical equipment, such as batteries and water storage.

The following minimum loads must be used in the structural design:

- Wind: 90 mph (40.2 m/s) (3-second gust), Exposure Category C (if tie-downs are not used, you MUST show that there is no overturning or uplifting with a safety factor of 2)
- Railings: 200 lb (890 N) concentrated load applied in any direction at any point at the top of the rail
- Interior Floor, Decks, Ramps: 50 psf (2.39 kPa) live load
- Means of egress components: 100 psf (4.78 kPa)
- Roof: 20 psf (0.958 kPa) live load
- Soil: 1000 psf (4.79 kPa) load bearing pressure on top of the soil
- Additional structural design requirements at the post-Event house location (to be determined by the engineer of record).

## ***10.4 Inspections***

Inspections will cover the inspection of sizes; of structural, electrical, and mechanical systems; and of a team's compliance with applicable sections of IRC2003, NEC2002, Rules and Regulations, [Solar Decathlon Accessibility Requirements and Guidelines](#), and [Battery Requirements and Guidelines](#).

### ***10.4.1. Pre-Event Inspections***

Solar Decathlon Inspectors will visit each team at its institution and inspect the work in progress for compliance. Inspectors anticipate spending up to two days with each team for Pre-Event Inspections and identification of areas requiring corrective actions. The Organizers will work with each team to arrange appropriate dates and times for Pre-Event Inspections.

### ***10.4.2. Event Inspections***

Each team participating in the Event must present its house for inspection before the Contests to verify compliance. The order of Event inspections will be determined in a drawing. Teams that fail to present their house at their designated time will drop to the back of the queue and will risk not having enough time to complete the inspection process. In addition, spot checks for compliance may take place



during and immediately after the Contests. Modifications to the team's electric car beyond the manufacturer's specifications are not permitted. The top five overall finishing houses and cars may be impounded immediately following the Contests for a final Inspection.

After Event inspections, teams will have 24 hours to bring an identified violation into compliance, or the team will be subject to a penalty. Teams may not be able to compete in any Contest until inspections have been passed.

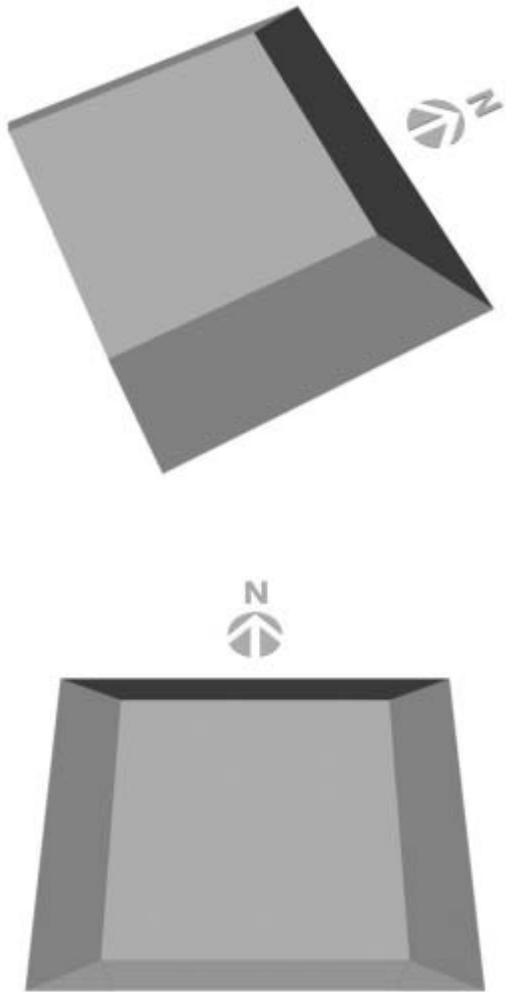
## ***10.5 The House and Site***

### ***10.5.1. Team Lots***

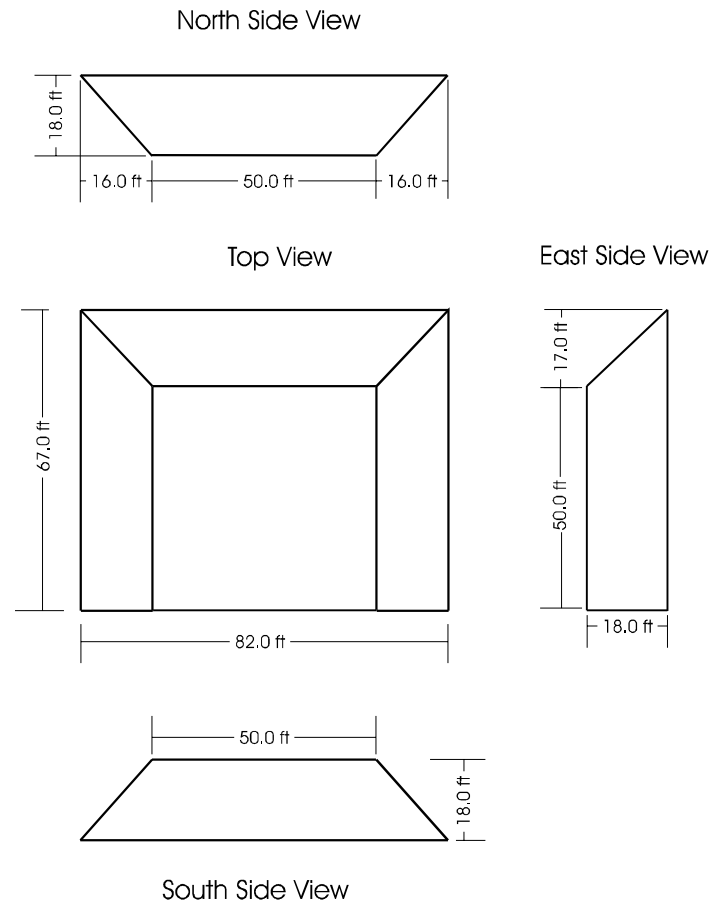
Teams will be allowed roughly 5500 ft<sup>2</sup> (511.0 m<sup>2</sup>) of nearly level, unobstructed land and will have three to four days to assemble their houses on the National Mall. Assume that some minor leveling of the floor deck will be necessary. There are no limits on materials or type of construction as long as applicable codes are followed. The house can either be transported to the site already assembled or transported and assembled on site, as long as it does not damage the site. No digging will be permitted except for tie-downs needed to meet wind-loading requirements. Large stakes or screws, similar to those used for circus tents, may be used to anchor the structures. Screws or stakes used with tie-downs are limited to 18-in. (45.7 cm) vertical depth. The lot size will be 82 ft (25.0 m) east to west by 67 ft (20.4 m) north to south. Please refer to Figures 1 and 2.

### ***10.5.2. Solar Envelope***

To protect a neighbor's right to the sun, each house and all items associated with the house must stay within the solar envelope shown in Figures 1 and 2.



**Figure 1: 3-D view of solar envelope**



**Figure 2: Solar envelope dimensions**

### *10.5.3. House Sizing*

Houses are restricted to a maximum of 800 ft<sup>2</sup> (74.3 m<sup>2</sup>) of total building footprint. The perimeter of the projection of the house onto a horizontal plane from plan view cannot contain an area greater than 800 ft<sup>2</sup> (74.3 m<sup>2</sup>). Any house component (e.g., ADA ramps, HVAC condenser, decks, porches, wastewater tank, supply water storage container, pressure pump) that is not part of the enclosed space and is not part of the solar array or energy storage system will be excluded from the 800-ft<sup>2</sup> (74.3 m<sup>2</sup>) footprint limitation but must be within the solar envelope. The house must have a minimum of 450 ft<sup>2</sup> (41.8 m<sup>2</sup>) of conditioned interior space measured as floor area from the inside of the exterior walls.

### *10.5.4. Vegetation*

Teams are permitted to bring potted vegetation to enhance the aesthetic or energy characteristics of their houses, provided that the vegetation does not violate the solar envelope. Vegetation will not be considered part of the solar array. Vegetation may be placed and moved around each team's lot until the end of the Assembly. After that, the vegetation will remain stationary until the conclusion of all the Contests and tours.

### *10.5.5. House Entryways*

Teams have the freedom to place the main entry to their house on any side of the house. However, teams must provide a walkway leading from the main street of the solar village to the main entrance of the house.

## **10.6 Energy**

### *10.6.1. Generators*

Teams may provide a generator from which they may charge their energy storage devices. Operation and refueling of generators is limited to times approved by the Organizers. Generators should be used only to complete Contests that teams would otherwise be unable to finish with power supplied by their solar array. However, teams will be assessed significant penalties for charging their energy storage devices with generators. In general, penalties will be greater in proportion to increases in the length of a generator's run-time and in the amount of a generator's energy production. Penalties will be applied during any part or all parts of Contests 5 through 10. Generators may be used only after notifying the Project Manager of the intention to use the generator.

Generators must be equipped with secondary containment systems that can accommodate all of the oil, fuel, and coolant that the generator contains at maximum capacities.

### *10.6.2. Solar Cell Technology Limitation*

Photovoltaics must be commercially available to all registered teams at a price not to exceed US \$5 per watt (watt peak at Standard Test Conditions [STC]) for bare cells (teams may pay extra for cutting, tabbing, or lamination of the cells). For encapsulated modules, photovoltaics must be commercially available to all registered teams at a price not exceeding US \$10 per watt (watt peak at STC). Substantial modification of the crystal structure, junction, or metallization constitutes manufacture of a new cell.

### *10.6.3. Energy Storage Location*

All energy storage devices (e.g., tanks, batteries, bladders, mass components) must be located within the 800-ft<sup>2</sup> (74.3 m<sup>2</sup>) footprint.

### *10.6.4. Flywheel Storage*

No flywheels of any kind will be permitted for electrical or any other type of energy storage.

### *10.6.5. Batteries*

Teams are allowed to use battery systems in their houses and cars for storage of electrical energy. The battery system for the car must be the car manufacturer's original equipment. Submittals of battery data shall be based on the manufacturer's published specifications provided by the team. Batteries must be available in sufficient quantities to be accessible to all participating teams. The battery modules may not be modified in any manner, for example, by using electrolyte additives; making case modifications; or adding, removing, or modifying plates. However, teams are permitted to add distilled water to vented (flooded) lead-acid batteries for maintenance purposes. Primary Batteries: The use of primary (non-rechargeable) batteries is limited to smoke detectors only. Secondary Batteries: The use of secondary batteries (rechargeable) for items such as laptop computers is permitted, provided that all laptops or similar devices used for Contest purposes are to be recharged from the house's electrical system.

### *10.6.6. Energy Collection*

Global solar radiation received by the house without artificial external augmentation is the only source of energy with which houses, tasks, and the electric car will be permitted to operate. Direct and diffuse radiation are considered forms of global solar radiation. All components used to convert global solar radiation to thermal, electrical, or mechanical energy shall be considered part of the solar array regulation. The following exceptions to the Energy Collection regulation apply:

- Energy stored in the house battery system or other Contest-related secondary batteries (e.g., laptop batteries, uninterruptible power supply systems) and the vehicle battery system when Assembly is completed.
- Use of a generator or other non-solar-power source to charge the electrical-storage system.

- Additional water associated with the supply and consumption of energy above and beyond the water supplied at the beginning of the Contest.

#### *10.6.7. Solar Array*

At any given moment, the solar array comprises all components that are involved in the conversion of solar energy for use by the house, for tasks, and by the vehicle. In addition to direct energy conversion components (such as photovoltaic cells), the solar array includes any reflective surfaces, shading surfaces, refractive lenses, solar thermal collectors, or any means of passive solar collection. The solar array cannot be outside the 800-ft<sup>2</sup> (74.3 m<sup>2</sup>) footprint in any way. The entire solar array must be integrated into the structural envelope, or skin, of the building.

#### *10.6.8. Thermal and Electrical Storage System Sizing*

Thermal and electrical storage systems sized for annual loads may be very large and costly in contrast to those needed for the purposes of the Competition. Therefore, teams are permitted to present a house containing thermal and electrical storage systems that are downsized from, or smaller than, the sizing indicated by annual simulation results.

### **10.7 Water**

#### *10.7.1. Quantity*

In drawings and submittals, teams must indicate all of the water that their entry requires during the Event.

#### *10.7.2. Supply*

Water will be supplied to teams at the conclusion of the Assembly phase. The intent is that all teams shall be ready to receive water before the water truck arrives on the Mall, so all team storage systems can be filled on the same day. Two gravity-fed water trucks will be available to fill the house's water storage systems. They will begin at the southwest and northeast corners and proceed counter-clockwise. The water trucks are restricted to gravel roads on the north and south sides of the Mall and are restricted in the height to which they can supply water. All water supply tanks must have easily accessible, 4-in. (10.2 cm) minimum diameter caps on the gravel road side of the house (north for teams on the north side of Mall, south for teams on the south side). All water tank caps must be less than 6 ft (1.83 m) from ground level. If teams have other water tanks higher than the 6-foot (1.83 m) cap limit, they are required to pump the water to the higher storage tanks from the tank of their own that meets the 6-foot (1.83 m) cap limit. The water trucks can NOT supply water higher than 6 ft (1.83 m).

Water will be supplied only once without penalty. After that, teams may request additional water, which may be subject to availability (indeterminable delay, depending on quantity needed) and a penalty. Teams should use a supply tank with enough capacity (plus an appropriate safety factor) to meet all their water needs throughout the Event. Contest requirements suggest a 250-gallon (946 liters) minimum; a team may require more, depending on appliances, cooking, and unforeseen events. No additives of any kind may be added to this water. This water is not for consumption at any time. To comply with Regulation 10.5.3: House Sizing, teams choosing to place their water supply storage container outside the 800 ft<sup>2</sup> (74.3 m<sup>2</sup>) footprint must prove to the Organizers in their Drawings and Submittals that the container is not part of “the energy storage system.”

#### *10.7.3. Distribution*

Teams are responsible for distributing water within their houses. This includes all necessary pumps, tanks, lines, valves, etc. All pumping power to distribute water must come from the house energy system.

#### *10.7.4. Rainwater Collection*

After Assembly is completed, teams may gather rainwater in their building footprints and use this water for any purpose. However, catchment system design and installation must be approved and stamped by a public health official. Because of Department of Public Health rules and concerns, unapproved catchment systems will not be allowed.

#### *10.7.5. Thermal Mass*

Any water used for thermal mass must be contained in a stand-alone system, which will be sealed off after the initial filling. Teams may use water as thermal mass to substitute for more common materials such as concrete masonry units (CMUs), concrete floor slabs, or brick. Water used for this purpose cannot be mixed with any other substance. Water will be supplied for thermal mass purposes and will have the same requirements as those for supply water.

#### *10.7.6. Evaporation*

Teams may use water for evaporation purposes. Evaporation must be included in the water use estimation. Teams may request additional water to compensate for evaporation after scoring begins; however, water delivery may be subject to availability (indeterminable delay, depending on quantity needed) and a penalty.

#### *10.7.7. Watering Vegetation*

Water from the house water system may be used to water any potted vegetation associated with the house.

#### *10.7.8. Wastewater*

All drains for appliances or sinks need to be routed back to a 350-gallon (1325 liters) minimum capacity drum to ensure that wastewater is not dispersed onto the National Mall turf or into storm drains. The wastewater drum must have a minimum 4-in. (10.2 cm) diameter cap, no higher than 6 ft (1.83 m) from ground level, that is easily accessible, on the gravel-road side of the house. All wastewater and water used in Contest 7: Hot Water must be stored in the wastewater drum. During the Event, dumping of water on the lot will not be permitted, according to NPS rules. Any dumping of water will incur a point penalty. All substances used in combination with water to clean the house, dishes, utensils, etc., must be nontoxic and preferably biodegradable. Teams could incur a point penalty for any toxic substances that are found in the wastewater drum. Teams will be required to provide the drum and support this drum so that it does not damage the National Mall turf. Teams are not required to place the wastewater drum within the 800-ft<sup>2</sup> (74.3 m<sup>2</sup>) footprint, but the drum must be located within the solar envelope.

#### *10.7.9. Wastewater and Thermal Storage Water Removal*

During Disassembly, all wastewater and thermal storage water shall be removed by a wastewater truck in a manner similar to the way in which the water was delivered. The wastewater truck will be equipped with a pump to aid in removal. Two wastewater trucks will begin at the northwest and southeast corners of the Solar Village and proceed clockwise in emptying wastewater and thermal storage tanks.

### **10.8 Electric Car**

#### *10.8.1. Pushing and Pulling*

In no case shall regenerative braking be engaged while pushing or pulling the car. Except for the following situations, the team's car may not be pushed or pulled during Contest hours:

- **Emergency:** In an emergency or breakdown situation, the car must be removed from the road. In this circumstance, the car may be towed back to Headquarters for inspection and repair.
- **Accidents and Re-inspection:** All accidents involving the car or support vehicles must be reported immediately to Solar Decathlon Headquarters. In case of an accident involving personal injury or property damage (or both), notification of the appropriate emergency medical services and public safety officials shall take priority. Notification to the school's insurer shall be made as soon as practicable. If a car is involved in an accident, it must be re-inspected by an Inspector before reentering the Contest. The Inspector may require that repairs be made before the team can resume the Contest.

- Impound: It may be necessary to push or pull the car to the impound area.

#### *10.8.2. NPS Rules*

Teams are permitted to drive the electric vehicles on National Mall turf to enable charging or parking within a carport or garage or area close to the team's house. When an electric vehicle enters or exits the National Mall, it must be "walked" (accompanied by a student Team Member on foot in front of the car). The electric car must be walked from the parking area, carport, or garage to the street and vice versa.

#### *10.8.3. Driver Requirements*

Only Decathletes are allowed to drive the team's electric vehicle for Contest 10: Getting Around Activities. All drivers at all times must have a valid driver's license and be 18 years of age or older.

Teams are required to include at least one passenger for all driving activities. During Contest 10: Getting Around Activities, that one passenger must be a Decathlete who has a means of communicating with the Decathletes remaining at the team's house. Teams must provide their own means of safe communication while operating the electric car. At all other times during the Event, that one passenger must be a Decathlete, Contest Official, member of the Event Staff, Judge, Juror, Inspector, Observer, Organizer, Rules and Regulations Committee member, or other person associated with the Solar Decathlon. Teams may have more than one passenger (provided they have one seat and safety belt per passenger), but at least one passenger must meet the requirements described here. All passengers at all times must have a valid driver's license and be 18 years of age or older.

#### *10.8.4. The Car*

Organizers will supply each team with an electric car. Proof of insurance must be kept with the vehicle at all times. Teams cannot alter the vehicles in any way. Teams may start the Contest with fully charged batteries in the vehicle, but any subsequent recharging must be supplied from energy generated by the house.

#### *10.8.5. Inspections and Accessories*

Before the team will be allowed to compete with its car, the car will be checked for compliance with the following manufacturer's specifications:

- Battery
- Tires
- Drive system
- Charging system



- Brakes
- 12 volt system (lights, horn, power plug).

The car also must have the following accessories installed at the Competition:

- Charge port locks
- Batteries sealed and marked to provide ready evidence of tampering after the start
- A logbook assigned to each vehicle that will provide written backup documentation to all vehicle activity
- Event decals supplied by Solar Decathlon Organizers.

## ***10.9 Desiccant Systems***

If a desiccant system is used in the house, it must be regenerative. To ensure that desiccant systems function in a steady-state fashion, the desiccant material or device must be easily weighable. The device or material will be weighed before and after the Contests. Teams will be assessed a penalty at the end of the Contests for having a desiccant material or device that weighs more than its initial weight.

## ***10.10 Thermal Storage***

All thermal storage devices (“mass”) must be made of stable, nontoxic materials. Material Safety Data Sheets (MSDS) must be submitted for all heat transfer fluids for approval. All liquid-based thermal storage systems must be marked with the NFPA’s Hazard Warning Diamond appropriate to the technology.

## ***10.11 Appliances***

The appliances used in Contest 6: Appliances must meet the following requirements or no points will be rewarded for the particular Contest Activity with which the appliances are associated.

### ***10.11.1. Refrigerator/Freezer***

Each team must provide a refrigerator and freezer with a minimum of 15-ft<sup>3</sup> (0.425 m<sup>3</sup>) combined interior capacity. Any attached freezer compartment must have a separate door from that of the refrigerator compartment and a minimum of 3-ft<sup>3</sup> (0.085 m<sup>3</sup>) interior capacity. Teams must submit manufacturers’ specifications on the refrigerator’s interior volume based on the Association of Home Appliance Manufacturers (AHAM) standard, AHAM HRF-1-2001. For custom refrigerators, teams must submit volume calculations based on the same standard.

Teams may disable the automatic defrost function on their refrigerators and freezers, if it is deemed necessary to maintain temperature control.

Teams may use the refrigerator only to store a reasonable amount of drinking water or other beverages and food for the cooking tasks. The use of an integrated icemaker is allowed only after the Contest Week begins. Teams may not put any frozen or chilled items from outside sources in the refrigerator or freezer, because this would violate Regulation 10.6.6.

#### *10.11.2. Clothes Washer*

The “Clothes Washing Tasks” Contest Activity of Contest 6: Appliances requires teams to wash 12 large cotton bath towels on several occasions. Teams must use residential-sized washing machines that operate automatically and have both a wash and rinse cycle.

#### *10.11.3. Clothes Drying*

The drying method may include active drying (e.g., machine-drying), passive drying (e.g., on a clothes line), or any combination of active and passive drying. All drying methods that require the towels to be visible must be demonstrated to the Architecture Jury and Dwelling Panel of Judges as they tour the houses.

#### *10.11.4. Dishwashers*

Dishwashers must have a minimum capacity of six place settings according to the manufacturer’s specifications. A single place setting is defined as a dinner plate, a salad plate, a bowl, a cup and saucer, two forks, a knife, and a spoon. Dishwashers must operate automatically and must have a wash and a rinse cycle.

#### *10.11.5. TV Monitor*

The TV monitor must be a minimum of 19 in. (48.3 cm) according to the manufacturer’s stated monitor size. The computer and TV monitors must be separate devices.

#### *10.11.6. Computer and Computer Monitor*

The computer monitor must be a minimum of 17 in. (43.2 cm) according to the manufacturer’s stated monitor size. The computer and TV monitors must be separate devices. The computer may be a notebook, laptop, or desktop computer.

## Summary of Revisions

March 12, 2004

- Activated links to *Solar Decathlon Accessibility Requirements and Guidelines* and *Battery Requirements and Guidelines* documents.
- Revised Regulation 10.3 to achieve consistency with 2003 International Codes and 2002 National Electric Code.
- Moved battery-related requirements from Regulation 10.3 to the *Battery Requirements and Guidelines* document.
- Revised Regulation 10.5.5: House Entryways.

November 2, 2004

- Revised Regulation 10.2: National Park Service (NPS) Regulations regarding teams' financial responsibilities for any damage they cause to the National Mall.
- Added an additional minimum load to Regulation 10.3.3: Structural to be used in structural design for "means of egress" components.
- Provided clearer solar envelope drawings (Figures 1 and 2) in Regulation 10.5.2. Note that the dimensions have not changed.

## Contests

The Solar Decathlon Competition consists of 10 separately scored Contests. Contests contain one or more Contest Activities. For example, Contest 5: Comfort Zone consists of four separately scored Contest Activities. The team with the highest total points at the end of the Competition will win. The table below lists the 10 Contests and the point values assigned to each.

Contest Number	Contest Name	Available Points
1	Architecture	200
2	Dwelling	100
3	Documentation	100
4	Communications	100
5	Comfort Zone	100
6	Appliances	100
7	Hot Water	100
8	Lighting	100
9	Energy Balance	100
10	Getting Around	100
<b>TOTAL</b>		<b>1100</b>

There are three ways to earn points. Most Contest Activities are one of the following three types, but some of the Contest Activities are a combination of two types.

- Successful task completion
- Continuous performance measurements
- Subjective evaluation by the Architecture Jury or a Panel of Judges.

There are several different ways points are awarded for successful task completion and continuous performance measurements. For successful task completion, in some cases, points are awarded on an all-or-nothing basis. In other cases, points are awarded on a linearly increasing scale as a function of “closeness to completion.” For continuous performance measurements, points are either awarded every 15 minutes during scored periods of the Event, at the end of each day, or at the conclusion of the Contest Week when performance requirements are met or partially met. To clarify, scored periods include all the 15-minute increments between 8 a.m. on the first day of the Contest Week and 5 p.m. on last day of the Contest Week, with the exception of those periods during which scoring is suspended for public tours. Public tour schedules will be published in the Event Schedule.

The scoring of the Contest Activities based on subjective evaluations by the Architecture Jury or a Panel of Judges is more flexible than the scoring of the objective Contest Activities described above. However, for the sake of fairness, it is important that there is consistency. To encourage consistency among all the subjectively judged Contest Activities, the Jurors and Judges will be encouraged to use the following procedure to facilitate the subjective scoring process:

### ***Guidance for the Architecture Jury and Panels of Judges***

1. Teams have been given the option of preparing [brief contest reports](#) for many of the subjectively judged Contest Activities. Reports will be made available to the Architecture Jury, and the Dwelling, Web site, House Tour, Indoor Environmental Quality, Hot Water, and Lighting Panels of Judges. Before arriving on the Mall to perform evaluations, review the reports submitted by the teams to gain some familiarity with each team’s efforts in the particular area being evaluated. The reports should make the judging process at the Event more efficient. If questions arise in the review of the contest reports, you may discuss those questions with the appropriate Contest Official at the Event.
2. Place each team into one of four classes. See below for the range of percentage integers associated with each class. Contest Activity guidelines are included in each Contest Activity description.

Class #1: ECLIPSES Contest Activity Guidelines	91 – 100% of available points
Class #2: EXCEEDS Contest Activity Guidelines	81 – 90% of available points
Class #3: EQUALS Contest Activity Guidelines	61 – 80% of available points
Class #4: APPROACHES Contest Activity Guidelines	0 – 60% of available points

You are not required to place a uniform number of teams in all classes or to place at least one team in every class. For example, if you determine that no teams are worthy of class #1, there would be no teams with scores greater than 90%. Note that the placing of teams into classes (as a first step toward assigning an eventual percentage integer) is encouraged to ease the process of evaluating so many teams at one time.

3. After all the teams have been placed into a class, Jurors and Judges should assign each team a specific percentage integer from 0% to 100% according to ranges established for the appropriate scoring classes. If it is possible to further separate teams within a particular class, assigning different percentages within the allowed range of the particular class is encouraged. The assigned percentage may fall anywhere within the range associated with the class. If it is not possible to further separate teams within a particular class, it may be appropriate to assign each team in a particular class the same percentage.
4. Discuss your evaluation of each team as a Jury or Panel of Judges—as a whole group—until a consensus percentage is reached for each team.
5. After assigning each team a percentage integer, the percentages should be submitted to the Contest Official. The Contest Official will then give the percentages to the Scoring Official, who will convert them into an actual score based on the total number of available points for the Contest Activity being judged. Prior to posting points, the Scoring Official will apply any applicable penalties that may have been incurred.
6. Submit a brief summary of scoring justifications for each team to the Contest Official. A summary of the Jurors' and Judges' justifications will be provided as feedback to the teams so they might better understand why the Jurors and Judges evaluated the teams as they did.

## Contest 1: Architecture

The Architecture Jury will evaluate the houses according to the following principles:

### ***Firmness:***

- Strength, suitability, and appropriateness of materials for the building
- Balance between the need for solidity and strength and the challenge of portability and ease of construction
- Integration of structure and enclosure

### ***Commodity:***

- Ease of entry into the house and circulation among the public and private zones of the house, as well as the served and service spaces
- Architectural strategy used to accommodate the technologies (especially the photovoltaic array) required to run the house
- Generosity and sufficiency of space to allow all of the activities required during the Contests to take place

### ***Delight:***

- Surprises, unusual use of ordinary materials, or use of extraordinary materials
- Sufficiency of architectural attention given to the experiential relationship between inside and outside
- Lasting impression: Is the house memorable in any way? In the interior? From the exterior?
- Balance of attention paid to all sides of the house

Contest Activity	Points Available
Architecture Jury Evaluations	200
<b>TOTAL</b>	<b>200</b>

## Contest 2: Dwelling

This Contest challenges the teams to design and build a house that will appeal in all ways to potential homebuyers and homebuilders. The Panel of Judges for Contest 2 could include representatives from the interior and industrial design professions, the building industry, writers, and interested members of the public. The Panel will judge this Contest according to two sets of criteria: livability and “buildability.”

### ***Livability:***

The Panel will evaluate the house to determine its appeal to a home-buying client or clients that have adequate financial resources, are seeking a small house with sustainable features, and do not want to pay energy bills in the future as a matter of principle. The Panel will be encouraged to consider the following in their evaluations:

- Appearance and overall impression of the interior, exterior, and the relationship between the interior and exterior
- Ease of traffic flow on the exterior, within the interior, and from the exterior to the interior
- Effective, innovative, and flexible space planning within the limited space
- Convenience of features (e.g., windows, shades, electronics, and mechanical equipment) requiring active operation
- Ease of care and maintenance
- Other aspects of the house not included in this list that contribute to the livability of the house.

### ***Buildability:***

The Panel will evaluate the house to determine its appeal to small or large homebuilders (or both). The Panel will be encouraged to consider the following in their evaluations:

- Reproducible features for mass production
- Required construction methods (simpler is better)
- Anticipated construction labor and transportation costs (lower is better)
- Flexibility of design and construction for different climates, budgets, and house sizes
- Marketability of house (materials costs not considered)
- Other aspects of the house not included in this list that will contribute to the buildability of the house.



<b>Contest Activity</b>	<b>Points Available</b>
Dwelling Panel Evaluations	100
<b>TOTAL</b>	<b>100</b>

## Contest 3: Documentation

### *As-Built Drawings and Submittals (40 pts):*

The Architecture Jury and an Engineering Panel of Judges will judge the as-built drawings and submittals according to the following criteria:

- Efficiency
- Organization
- Comprehensiveness
- Quality
- Creativity.

### *Schematic Energy Analysis Report (40 pts):*

Each team will be scored on the contents of a report that summarizes its pre-design/schematic design analysis of energy performance for its house. Teams are encouraged to apply the concepts of whole building design to their pre-design analyses, including the use of computer simulations to model alternatives. The Energy Analysis Panel of Judges will evaluate the report according to the following guidelines:

- Assumptions: Significant assumptions regarding the analysis or simulation (or both) are identified
- Simplifications: The simulation is as simple as possible without compromising accuracy, and all significant simplifications are identified and justified
- Improvisation: Currently available software may not contain routines for all situations, and any necessary improvisations to simulate a specific component or system are documented and justified
- Energy performance: Design steps taken to optimize energy performance, including predicted annual energy requirements of the proposed design, are discussed.

The Panel of Judges will be looking for effective communication and synthesis of the team's design and analysis process with focus on the application of sound modeling and engineering principles and creative analysis according to the following criteria.

Communication:

- Effectively communicates the intended integration of building elements and systems
- Communicates the analysis steps supporting design recommendations including, parametric and optimization studies and custom and specialized analysis for specific components
- Demonstrates effective, creative use of graphics to condense and summarize key analysis

- Conveys the design process (architectural programming, design goals, whole building strategies)
- Includes summary drawings of plan and elevation to convey key geometrical and architectural information
- Demonstrates organization and consistency in main and supporting documents
- Innovative visual style enhances organization and access to report findings.

#### Engineering:

- Summarizes clearly the thermal and electric loads used in the analysis, and comparison or reference (or both) to standard load assumptions such as *ASHRAE Standard 90.2*
- Summarizes clearly the key assumptions such as envelope characteristics, lighting level, and thermal set-points
- Demonstrates awareness and testing of design against “high performance” energy efficiency strategies
- Demonstrates awareness and attempt to integrate building architecture and systems
- Demonstrates innovative and creative analyses where standard tools are limited
- Identifies clearly the key assumptions and supporting information where engineering approximations are required
- Demonstrates quality control checks (e.g. order-of-magnitude analysis, corroborating data from multiple sources, sign-off by multiple reviewers) on component and overall analysis.

#### **Final Project Summary (10 pts):**

Each team shall submit a report that describes the evolution of the design from conception to completion (Narrative) and reports the costs incurred during the Project (cost report). The Organizers will award points according to the following criteria:

- Timeliness: On-time submittal of final project summary
- Completeness: submission of all required elements of the project summary
- Presentation quality: Narrative and cost report are written in a format that will be suitable for conversion into Communications Materials
- Detail: Narrative and cost report efficiently condense a large amount of useful information into a relatively small number of pages
- Accuracy: A random sample of information in the cost report will be audited for accuracy.

#### **Pre-Event Project Deliverables (10 pts):**

On time, complete submittals of pre-event project deliverables (not including the as-built drawings and submittals, schematic energy analysis report, and final project summary) will earn up to 10 points.

<b>Contest Activity</b>	<b>Points Available</b>
As-Built Drawings and Submittals	40
Schematic Energy Analysis Report	40
Final Project Summary	10
Pre-Event Project Deliverables	10
<b>TOTAL</b>	<b>100</b>

## Drawings and Submittals (Contest 3 Details)

Teams must send drawings and submittals for the Project to the Organizers on three separate occasions. Ideally, the drawings and submittals are continual works-in-progress that culminate in the as-built set, which is judged as part of Contest 3: Documentation. The Organizers use the drawings and submittals to determine constructability, system operational parameters and requirements, Rules and Regulations compliance, and code and design standards compliance. The following is a brief description of the three required sets of drawings and submittals.

1. **Design Development Drawings and Submittals (due June 15, 2004):** The following description of the design development project stage is taken directly from *The Architect's Handbook of Professional Practice: Student Edition*:

“Decisions made in schematic design are worked out at a more detailed level to minimize the possibility of major modifications being needed during the development of construction contract documents. In design development the design team works out a clear, coordinated description of all aspects of the design, including architectural, mechanical, electrical, plumbing, and fire protection systems. Deliverables are similar to those of schematic design but are more detailed. They include drawings and specifications, an updated cost estimate, and, if required, the preparation of estimated schedules for construction. Again, written client approval provides a basis for subsequent work. The approved design development documents provide the basis for the construction documents increment, which sets forth in detail the requirements for construction.”

The Organizers will evaluate the design development set to determine whether a team will receive conditional approval (analogous to the statement above, “written client approval provides a basis for subsequent work”). The Organizers will thoroughly review the information contained in this set and identify any deficiencies and requirements for final approval.

2. **Construction Drawings and Submittals (due February 8, 2005):** The following description of the construction documents project phase is taken directly from *The Architect's Handbook of Professional Practice: Student Edition*:

“Once a design has been developed and approved, the architect prepares the drawings and specifications that set forth the requirements for construction. The development of the construction documents is an extension of the design process. Decisions on details, materials, products, and finishes all serve to reinforce the design concept—and begin the process of translating the concept into reality.

The drawings show, in graphic and quantitative form, the extent, configuration, location, relationships, and dimensions of the work to be done. They generally contain site and building plans, elevations, sections, details, diagrams, and schedules. In addition to drawn information, they may include photographs, other imported graphics, and printed schedules. Architectural, structural, mechanical, electrical, civil, landscape, interior design, and other applicable specialty drawings should be included.

The specifications outline the levels of quality and the standards to be met in the construction of the process. Addenda include additional information that is not covered by drawings or specifications. The set of construction documents should communicate to the contractor the quantities, qualities, and configuration of the elements required to construct a project.”

The construction set should address all the deficiencies and requirements identified by the Organizers in the design development set review. If the construction drawings and submittals are satisfactory, a team will receive Final Approval. Any lingering deficiencies and requirements must be addressed, and revised construction drawings and submittals must be sent to and reviewed by the Organizers before final approval can be granted. Teams that do not receive final approval may be asked to withdraw from the Competition.

3. **As-Built Drawings and Submittals (due August 9, 2005):** The following is a description of as-built drawings and submittals from [H-K Resources Pte Ltd](#).

“As-Built Drawings depict the final installed configuration (whether physical or functional). They indicate any construction deviations and show all features of the project as actually built. These drawings provide a permanent record of as-built conditions and aid as key references for future maintenance processes.”

The as-built set will be distributed to the Architecture Jury and the panel of engineering judges for their Contest 3: Documentation —As-Built Drawings and Submittals evaluations. Inspectors at the Event will also use this set to help them perform their inspections.

## Minimum Content Requirements

The **drawings** must include the following:

- *Table of Contents* (on first page after Cover Sheet)
- *Site Plan and Elevations:* Show placement of house and exterior tour route within Solar Envelope and show locations of car, water tanks, walkways, signs, vegetation, etc. Elevations (or dimensioned 3-D views) are required for verification of compliance with 18-ft. height rule.

- *Footprint and Conditioned Area Plan*: Clearly show estimated areas (using a program such as Brava Reader) for compliance with Regulation 10.5.3: House Sizing
- *Architectural*: Plans, elevations, sections.
- *Structural*: See [Regulation 10.3.3: Structural](#) for detailed structural requirements.
- *Electrical*: Sufficient detail to size and locate major components with the associated routing of conduit and duct systems for electrical power service and distribution, PV systems, lighting, data communication, lightning protection, ground fault protection, and data acquisition and control systems. Includes one-line diagrams. Also demonstrate compliance with *Battery Codes, Regulations, Best Practices and Contest-Specific Rules for the Solar Decathlon* document, which will be provided in the future.
- *Mechanical and Plumbing*: Sufficient detail to size and locate major components with the associated routing of piping, ducts, and plenums for plumbing, HVAC, and hot water heating systems.
- *Layouts*: Must contain sufficient detail to identify the layout of spaces, systems, furniture, and equipment, including material selections with colors, textures, finishes, etc.
- *ADA Compliance*: Demonstrate compliance with the [Solar Decathlon Accessibility Requirements and Guidelines](#) document. Show interior tour route.
- *System Schematics*: Solar electric, hot water heating, and other unique or unusual systems.
- *Construction and Assembly Process*: Explains the construction process, specifies the equipment to be used on site to aid the assembly process (e.g., cranes, forklifts), and estimates the time necessary to deliver and construct the house.
- *Disassembly Process*: Explains the disassembly process, specifies the equipment to be used on site to aid the disassembly process (e.g., cranes and forklifts), and estimates the time necessary to disassemble and remove the house from the Mall.
- Other important drawings not included in this list.

The **submittals** must include the following:

- Table of Contents
- Summary of changes: If there are changes to the drawings and submittals between the design development set and the construction set, provide a summary of those changes with the construction set. If there are changes to the drawings and submittals between the construction set and the as-built set, provide a summary of those changes with the as-built set.
- Structural calculations toward meeting PE Stamp requirements (See [Regulation 10.3.3: Structural](#) for detailed structural requirements).
- Calculations, drawings [to be included in 11 in. X 17 in. (or closest metric equivalent) set], and discussion of additional structural design issues not relevant to PE Stamp requirements. Examples of Project phases not relevant to PE Stamp requirements, but which may present additional structural design challenges, are the following: fabrication and construction; transportation to and from Washington, D.C.; assembly and disassembly; and operation of the house on site at the Event.
- Solar cell specifications
  - Copy of manufacturer's solar cell and module specification sheet(s)

- Manufacturer's name and contact information
  - Stock number, type, or description
  - Manufacturer's quote for cell or module area
  - Manufacturer's quote for performance
  - Cost (US\$) per watt for each cell or module.
- Battery specifications
  - Copy of manufacturer's battery specification sheet(s)
  - Material Safety Data Sheets (MSDS) obtained from the manufacturer
  - Manufacturer's name and contact information
  - Stock number, type, or description
  - Module voltage (e.g., 6 V, 12 V, or 24 V)
  - Bus voltage
  - Number of modules to be used in the house
  - Manufacturer's specifications, including capacity (kWh), weight (lb.), and cost (US\$)
  - Spill and damage protocols and procedures (if these are not provided in the MSDS, the team must obtain this information from the manufacturer and submit it with the MSDS).
- Information demonstrating compliance with all applicable codes, Solar Decathlon Rules and Regulations, and construction industry standards that is not clearly evident in the actual drawings (e.g., calculations showing that the battery enclosure ventilation is sufficient to maintain compliant hydrogen concentrations). Include a summary of unlisted electrical components and justifications for choosing unlisted components.
- Manufacturers' data sheets for all major house components including, but not limited to, kitchen appliances, hot water heating system components, water supply system components, solar electric balance of system components, HVAC system components, thermal storage devices and tanks, primary structural components, insulation, windows, and unusual finishes, fixtures, and furnishings.
- Material Safety Data Sheets (MSDS) required for all materials to be used at the Event that require an MSDS, such as cleaning solvents, glycol, rubber cement, rubbing alcohol, etc.
- Total estimated water usage during the Event; the Organizers need to know how much water is required to meet all the houses' needs during the Event.
- Any other important supplemental information not included in this list.

Note: Some information listed under the submittals requirements may be more appropriately located in the drawings as notes or tables. It is up to the teams to decide whether information belongs in the drawings or submittals. The Jury and panel of engineering judges will evaluate how well the teams organize the information in the drawings and submittals.



## Format Requirements

- Drawings must be 11 in. X 17 in. (or closest metric equivalent).
- Submittals must be 8.5 in. X 11 in. (or closest metric equivalent).
- There are no page number limits. The Architecture Jury and Engineering Panel of Judges will determine whether an appropriate amount of information has been conveyed in the Drawings and Submittals.
- Spiral bindings are required for both the drawings and supplements.
- The Panel of Judges for the As-Built Drawings and Submittals Contest Activity will evaluate both sets. The Organizers will use both sets to determine conditional and final approval.
- Five hard copies of the design development and construction drawings and submittals sets are required. Fifteen hard copies of the as-built drawings and submittals are required because they must be distributed to all the judges. In addition to the hard copies, electronic files of the entire 11 in. X 17 in. (or closest metric equivalent) drawings are also required. The electronic files must meet the following requirements. If they do not meet these requirements, they will not be used in any brochures, signs, programs, or other promotional materials:
  - Images must be 11 in. X 17 in. (or closest metric equivalent) at 300 dpi.
  - TIF files are preferable, but EPS or Adobe Illustrator (Version 5.5 or higher) files are also acceptable. AutoCad or similar files will not be accepted.
  - Mac platform files are preferable, but PC platform files are also acceptable. Although problems with PC platform files are rare, they do sometimes occur, so if you want to make sure the Organizers can access your files, you should consider Mac platform files.
  - Files must be in RGB, 8-bit color.
  - Only compressed files using Stuffit or ZIP software will be accepted.
- A standard architectural title block must appear on the right side of every page of the drawing set. The title block may be toward the top, middle, or bottom of the page, but it must be placed on the right side.
- The scale of all plans (except Site Plan), elevations (except Site Elevations), and sections must be 0.25 in. = 1 ft-0 in. (or closest metric equivalent). However, a graphic scale must be used so that the drawing can be reduced or enlarged without consequence. The Site Plan and Site Elevations must be 0.125 in. = 1 ft-0 in (or closest metric equivalent).
- Construction details should be at an appropriate scale.
- There must be a 0.5 in. (or closest metric equivalent) margin around the entire page.
- Refer to *The Architect's Handbook of Professional Practice: Student Edition* for suggested drawing conventions regarding page numbers, text heights, layers, dimensions, symbols, specifications, etc.
- The cover sheet of the drawings set, to be used as quick reference by the Architecture Jury and the Dwelling Panel in their evaluations, must contain the following information:
  - Title
  - Floor plan

- Site plan, i.e., location relative to other houses
  - Image of house exterior (can be a photo or computer rendering)
  - 250-word mission statement.
- Send the Drawings and Submittals package to the following address:  
 Mike Wassmer  
 National Renewable Energy Laboratory  
 Mail Stop 3214  
 1617 Cole Blvd.  
 Golden, CO 80401
- To be considered on time, the package must arrive at NREL by 5 p.m. on the due date.

### Summary of Revisions

March 12, 2004

- Added bullet about page number limit
- Under bullet regarding information about compliance, added requirement regarding unlisted electrical components
- Activated link to *Solar Decathlon Accessibility Requirements and Guidelines* document
- Added mailing address to which Drawings and Submittals should be sent

November 2, 2004

- Added “Table of Contents” “Site Plan and Elevations,” and “Footprint and Conditioned Area” requirements to minimum content requirements, drawings section.
- Added “interior tour route” requirement to “ADA Compliance” bullet.
- Added requirements to minimum content requirements, submittals section. Regarding MSDS.
- Under format requirements, specified scale for the site plan and clarified purpose for cover sheet of drawings set.
- Added explanation of due date requirements.
- Equipment schedule requirement removed from minimum content requirements, submittals section. The Cost Report will serve as the equipment schedule. Even though this specific requirement has been removed, teams still have the option of including an equipment schedule in the drawings or submittals if they so choose.
- Added table of contents requirement to minimum content requirements, submittals section.

# Schematic Energy Analysis Report (Contest 3 Details)

## Submission Format

This report must be received by Mike Wassmer at [michael\\_wassmer@nrel.gov](mailto:michael_wassmer@nrel.gov) as either a Microsoft Word or Adobe PDF electronic file by 5 p.m. mountain time on June 15, 2004. The main body of the report may not exceed 30 single-sided pages, using a single-spaced 11-pt font. The pages must be 8.5 in. X 11 in. (or closest metric equivalent) and may include any embedded building plans and graphics that are appropriately placed in the body of the report. Appendix material (e.g., data sheets, simulation results, and screen captures) may be included, if desired. The appendix should have the same format as the body of the report and may not exceed 30 pages.

## Suggested Contents

The judging criteria for the schematic energy analysis report are described in [Contest 3: Documentation](#). In general, this report is intended to summarize the preliminary energy analysis supporting the development of the team's building design. Discussion should highlight key features of the team's design that were affected by energy analysis and simulation results. A typical discussion of key features of the design would include annual energy source estimates (e.g., PV and solar thermal); annual energy load estimates, including lighting, heating, cooling, and domestic hot water heating; and other loads (e.g., electric car charging). Additional overall results worthy of discussion could include Event site climate statistics, predicted monthly energy balance (energy collected versus energy used), space temperatures, or other indicators chosen to highlight the energy performance of the design.

There are no restrictions on the simulation tools that can be used for this analysis, but all such tools should be clearly identified. The Energy Analysis Panel of Judges will be looking for effective communication and synthesis of the team's design and analysis process, focusing on the application of sound modeling and engineering principles and creative analysis.

### Summary of Revisions

November 2, 2004

- Minor editorial changes.

## Project Summary (Contest 3 Details)

The material requested in these project summaries is important. It helps the Organizers stay in touch with the teams. It helps the Organizers respond efficiently to media inquiries. It provides potential sponsors with information. It provides important content for the communications materials (e.g. the Web site and competition program) that the Organizers are developing in preparation for the Event. And, it will become part of the content in the final report, produced by the Organizers after the Event, about the 2005 Solar Decathlon.

This material is also important to the teams. The teams can earn points in Contest 3: Documentation by submitting these summaries. It can be used to develop content for Web sites and house tours for Contest 4: Communications. It will help teams develop materials to find sponsors. It will help with any reporting requirements a team's school or sponsors might have. It mimics the kind of reporting many team members will have to do in their professional careers. And, it will prepare teams to answer the kinds of questions that visitors to their construction sites and to the Event on the Mall are sure to have.

The Organizers want accurate and meaningful information, not something invented to meet requirements. The deadlines for project summary submissions coincide with the preliminary Web site (April 15, 2004), design development (June 15, 2004), construction (February 8, 2005), and as-built deliverables (August 9, 2005). Project summaries should be submitted as either a Microsoft Word or Adobe PDF electronic file to [ruby\\_nahan@nrel.gov](mailto:ruby_nahan@nrel.gov). To be considered "on time," project summaries must arrive at their intended destination by 5 p.m. (mountain time) on the due date. If files are too large for an email attachment, please see [Instructions for Submitting Images](#) for information about submitting files via the Solar Decathlon FTP site. You must notify Ruby by email of file transmissions. The project summary should include, but is not limited to, the following:

### Team Information

- Team photograph: indicate names and titles of the people in the photo and follow the [Instructions for Submitting Images](#). If there has been no change in team members from one submission of a project summary to the next, there is no need to submit another photo.
- Team organization and contacts: The Organizers want to know how each team is organized and approximately how many students, faculty, and others (e.g. sponsors, volunteers, family members) are involved in each Project. The teams should provide contact information (name, title and/or Project title, mailing address, email, phone and fax numbers) for as many team members in leadership positions as possible (at a minimum, Faculty Advisor, team leader(s), communications, media relations, and house transportation contacts). Even if contact information doesn't change between submissions of project summaries, please resubmit this information.

## Narrative

- The narrative is the story of the Project to date, in narrative form [3 to 5 pages (no more than 5 pages), 11 pt. type, double spaced, 1 in. (or metric equivalent) margins]. Projects are works-in-progress; after the first project narrative submission, teams should update previous information.
- Team mission statement, goals, and values: What is the team's "personality?" What does the team want to accomplish? What does the team care about? What has changed and why?
- Discussion of design philosophy and house design: What is the point of the design? What is the team trying to say or trying to accomplish with this design? What will the house look like? What are some of the key features? Why is the team making the choices it's making? What makes the house stand out, or appear unique? How will the need for portability affect the design? What has changed and why? (Also see bullet about items of particular interest in the cost report information.)
- Characterize the team's accomplishments and planning: What did the team plan to do and why? What has it succeeded in doing and how? What has the team done that wasn't planned for and why? What are the team's future plans? What has changed and why?
- Teams are free to include images, but must follow [Instructions for Submitting Images](#).

## Cost Report

- The Organizers are looking for accuracy in the cost report. Teams will not be judged on the costs of their Projects. A Solar Decathlon Organizer with experience in construction accounting will perform random verifications on the cost reports.
- The cost report should contain detailed and itemized cost information (see following bullets) about the house, including but not limited to: floor, wall, and roof construction; insulation; electrical and plumbing systems; HVAC system and duct work; PV system and balance of system; water heating and balance of system; windows; shading (interior and exterior); interior features such as flooring, wall, and ceiling materials and finishes, cabinets, and fixtures; appliances and electronics; lighting (interior and exterior); exterior finishes; roofing materials; and anything else a visitor to the house could see or notice, especially if that thing is interesting.
  - Item description, model name and number, dimensions or size, manufacturer, and quantity
  - What is the retail cost of each item? (How much does the manufacturer sell the item for on the retail market?)
  - What was the cost of each item to the team? (How much cash did the team spend on the item?)
  - What is the retail value of any donations or in-kind donations the team received, and who made those donations?
  - For items of particular interest (things that stand out, that people can point to and ask questions about, that are unusual for any reason, that help the team tell its story) provide an explanation as to why that item was selected. What were the trade offs? Why is it better than something else, especially if another choice would be more conventional? Teams may briefly characterize these decisions in the cost report and provide greater explanation in the project narrative.

- The cost report should provide detailed and itemized cost information about the overall Project, including, but not limited to: fund raising, sponsor solicitation, promotional, advertising, communications and outreach efforts; educational materials; labor (not volunteer labor); travel, accommodation, and travel per diem; space, tool, machinery, and other equipment purchases or rental fees; freight, delivery, and transportation charges.
- Include answers to the following questions:
  - What is the cost (projected and actual) of the entire Project?
  - What is the cost of constructing the house?
  - What is the retail value of all contributions and in-kind contributions?
  - Who made those contributions?
  - What is the retail value of the house?

#### **Summary of Revisions**

March 12, 2004

- Added electronic submission information
- Added requirement to include information about projected and actual costs.

November 2, 2004

- Clarified submission requirements.

## Pre-Event Deliverables (Contest 3 Details)

This document identifies the project deliverables that are due to the Organizers through the beginning of the Event. Click on the links for more details, including formatting and submission requirements, about each deliverable. Links to details about deliverables for which links were not provided will be provided in the future. To be considered “on time,” deliverables must arrive at their intended destination by 5 p.m. (mountain time) on the due date.

Deliverable	Due Date	Submit To
<a href="#">Project Summary #1</a> <a href="#">Preliminary Web Site</a>	April 15, 2004	Email to <a href="mailto:ruby_nahan@nrel.gov">ruby_nahan@nrel.gov</a>
<a href="#">Project Summary #2</a> <a href="#">Schematic Energy Analysis Report</a> <a href="#">Design Development Drawings and Submittals</a>	June 15, 2004	Email to <a href="mailto:ruby_nahan@nrel.gov">ruby_nahan@nrel.gov</a> Mike Wassmer National Renewable Energy Laboratory Mail Stop 3214 1617 Cole Blvd. Golden, CO 80401
<a href="#">Project Summary #3</a> <a href="#">Construction Drawings and Submittals</a>	February 8, 2005	Email to <a href="mailto:ruby_nahan@nrel.gov">ruby_nahan@nrel.gov</a> Mike Wassmer National Renewable Energy Laboratory Mail Stop 3214 1617 Cole Blvd. Golden, CO 80401
Arrival and Departure Plan		
Computer Network Information Requirements	February 8, 2005	Information to be provided
Team Registration	Summer 2005	Web site URL to be provided

---

[Final Project Summary](#)

August 9, 2005

Email to [ruby\\_nahan@nrel.gov](mailto:ruby_nahan@nrel.gov)

[As-Built Drawings and Submittals](#)

August 9, 2005

Mike Wassmer  
National Renewable Energy Laboratory  
Mail Stop 3214  
1617 Cole Blvd.  
Golden, CO 80401

[Brief Contest Reports](#)

August 9, 2005

Email to [michael\\_wassmer@nrel.gov](mailto:michael_wassmer@nrel.gov)

[Meal Plans](#)

---

<b>Summary of Revisions</b>
-----------------------------

November 2, 2004

- Clarified by what time deliverables are due on due dates
- Added "Submit To" column for quick reference
- Added meal plans to list of items due on August 9, 2003.



## Contest 4: Communications

This Contest contains three Contest Activities: Web Site, House Tours, and Branding Effectiveness. A panel of communications experts will judge the Web Site Contest Activity. A panel of public relations experts will judge the House Tours Contest Activity. The Web Site and House Tours Panels of Judges will work together to judge the Branding Effectiveness Contest Activity.

### *Web Site (50 pts):*

#### Timeliness:

See [Web Site \(Details\)](#) for information about the April 15, 2004 and the fall 2005 deadlines.

#### Content

- Adherence to professional best practices for Web site content
- Audience-appropriate language and tone; average consumers make up the audience for the purposes of this Contest
- Originality, creativity, and interest
- Correct spelling and grammar
- Inclusion of content specified by the Organizers. See [Web Site \(Details\)](#) for more information
- Limited use and tasteful integration of Team Sponsor information and adherence to [Regulation 3.2 Event-Sponsor Recognition](#)

#### Design and Architecture

- Adherence to professional best practices for graphics, photos, color, and typography
- Design is audience appropriate, visually engaging, and consistently branded; average consumers make up the audience for the purposes of this Contest
- Interactive and multimedia elements add value to the site and function correctly
- Speed of load time is appropriately balanced with valuable use of graphics, multimedia, and scripting
- Limited use and tasteful integration of Team Sponsor logos and adherence to [Regulation 3.2 Event-Sponsor Recognition](#)
- Site architecture (organization) and navigation elements are simple, comprehensible, and represent the hierarchical organization of site content
- Graphical navigation elements are easy to use, consistent, and well integrated with content and design

## Coding

Adherence to guidelines and recommended best practices provided by the Organizers; see [Web Site \(Details\)](#) for more information.

## ***House Tours (40 pts):***

### Timeliness

A schedule for House Tour judging will be provided. Teams' tours will be judged "as is" at scheduled times.

### Content

- Audience-appropriate language and tone; average consumers make up the audience for the purposes of this Contest
- Originality, creativity, and interest
- Inclusion of content to be specified by the Organizers in the document House Tours (Details), to be provided in the future
- Limited use and tasteful integration of Team Sponsor logos and information. Teams must follow the [Guidelines for Sponsor Recognition on the National Mall](#) and [Regulation 3.2 Event-Sponsor Recognition](#)

### Presentation

- Demeanor of tour guides toward the public
- Innovative approaches to engaging visitors waiting in long lines outside the houses
- Appropriateness, effectiveness, and originality of tour materials
- Minimization of throwaway materials

## ***Branding Effectiveness (10 pts):***

Effective and appropriate use of key messages and images representing the teams' values, missions, purposes, and goals in the Project across all required components of Contest 4.

<b>Contest Activity</b>	<b>Points Available</b>
Web Site	50
House Tours	40
Branding Effectiveness	10
<b>TOTAL</b>	<b>100</b>

## Web Site (Contest 4 Details)

The first deadline for Web sites is April 15, 2004. By that date, the teams must submit a URL of their Web site to the Organizers (see Timeliness section below). The Web sites will not be judged at that time. A team of Web development professionals at the National Renewable Energy Laboratory (NREL) will evaluate the Web sites and provide feedback regarding content, design and architecture, and coding to the Solar Decathlon teams. Feedback will include suggestions for improving content, design, and architecture, as well as guidance for complying with coding requirements.

From April 15, 2004 until June 1, 2004, the NREL Web development team will review the Solar Decathlon teams' sites and provide suggestions to help the teams improve content, and design and architecture. What the teams do with those suggestions is up to them.

The NREL Web development team will also review Web site coding. Teams must implement the Web development team's suggestions to meet minimum coding standards on their Web sites. The Organizers will not link to any team's site from the main Solar Decathlon site if that team's site does not meet minimum coding requirements. The process of receiving approval for minimum coding requirements must be complete by June 1, 2004. At the final deadline in fall 2005 (exact date to be provided in 2005), the Solar Decathlon Communications judges will not judge any team's site that has not been linked from the main Solar Decathlon site.

The following details supplement and are organized according to the explanation of [Contest 4: Communications—Web Site](#). Team Web sites also must comply with [Solar Decathlon Regulation 3, Communications Materials](#).

### Timeliness

- April 15, 2004 deadline: Submit URL of team Web site via email to [ruby\\_nahan@nrel.gov](mailto:ruby_nahan@nrel.gov) by 5:00 p.m. MST on April 15, 2004.
- Fall 2005 deadline: The exact deadline for completion of Web sites for judging is dependent on the schedule for the Event, which will not be finalized until summer 2005. However, teams should plan on having their Web sites finalized before arriving at the Mall. They may continue to make changes and updates to their sites throughout the Event. All team Web sites linked from the Solar Decathlon site will be judged "as is" on the date that Web site judging begins. The date will be provided in 2005.

## Content

### ***April 15, 2004 Deadline***

- All Web sites will be reviewed and feedback provided based on the criteria listed in [Contest 4: Communications—Web Site](#), as well as on the additional criteria listed below.
- Web site content must identify the Project as the Solar Decathlon and recognize all Event Sponsors according to [Regulation 3.2, Event-Sponsor Recognition](#).
- Web sites do not have to contain content that would compromise a team's competitive edge in the final competition.
- The site must consist of a minimum of five pages.
- For the purposes of this review, average consumers make up the target audience for the site.
- The Web site should discuss the team's Solar Decathlon project and the team's progress and accomplishments to date, including (but not limited to):
  - Team mission statement, goals, and values
  - Design philosophy
  - Team organization
  - Project timeline and accomplishments to date
  - Overall Project budget and Project costs to date
  - Systems, materials, product selection, and retail costs (all donations and in-kind contributions must have an associated retail cost).
  - Teams may easily look to information gathered for their first [Project Summary](#) to develop the required content for their Web sites.

### ***Fall 2005 Deadline***



- All sites will be judged based on the criteria listed in [Contest 4: Communications—Web Site](#), as well as the additional criteria listed below.
- Web site content must identify the Project as being a Solar Decathlon Project and recognize all Event Sponsors according to [Regulation 3.2, Event-Sponsor Recognition](#).
- Web site content should be complete and comprehensive. There will be no allowances made for exclusion of content to preserve a team's competitive edge in the Competition.
- The site must contain considerably more content at the final deadline than it did at the April 15, 2004 deadline, and that content should reflect the current state of the Project. There will be no minimum or maximum page requirements.

- For the purposes of the competition, average consumers make up the target audience for the site.
- The Web site should discuss the team's Solar Decathlon Project, the team's progress and accomplishments to date, and the team's plans for the Event and Competition, including, but not limited to:
  - Project history, including, but not limited to, Project mission statement, original design philosophy, original team organization, original Project timeline and budget
  - Current team organization (if the team organization has changed over time, indicate the changes, including team organization for the Event and Competition)
  - Project timeline and accomplishments to date (if the timeline has changed from its original, indicate those changes and their rationale)
  - Overall Project budget and Project costs to date (if the budget has changed over time, indicate those changes and why they have changed)
  - Explanation of the house's design, including the solar energy and energy efficiency design strategies and technologies used in the house and the rationale for the use of those strategies and technologies. Also include the influence of transport, Assembly, and Disassembly on the design
  - Systems, materials, product selection, and retail costs (all donations and in-kind contributions must have an associated retail cost); indicate any changes in materials and product selection over time, and the rationale for those changes)
  - House transportation, Assembly, and Disassembly plan
  - Planned competitive strategies for the Competition and their rationale
  - The Web site's audience (average consumers) must be able to find the answers to the following questions:
    - What is the cost of the entire Project?
    - What is the cost of constructing the house?
    - What is the retail value of all contributions and in-kind contributions?
    - Who made those contributions?
    - What is the retail value of the house?
  - Teams may easily look to information gathered for each [Project Summary](#) to assist in developing the required content for their Web sites.




## Design and Architecture

- All sites will be reviewed and feedback provided based on the criteria listed in [Contest 4: Communications—Web Site](#).
- Web site design must include use of the Solar Decathlon logo to properly identify the Project according to [Regulation 3.2, Event-Sponsor Recognition](#).



## Coding

- April 15, 2004 and fall 2005 deadlines: All sites are required to meet minimum coding standards, listed below. Web development experts at NREL will review and provide feedback on the teams' Web sites from April 15, 2004 to June 1, 2004 to ensure compliance with these standards. Team Web sites that do not meet the coding requirements will not be linked from the Solar Decathlon Web site. Team Web sites that are not linked from the Solar Decathlon Web site will not be judged in fall 2005. No further feedback will be offered after June 1, 2004. Team Web sites will be judged on their compliance with the coding standards in fall 2005.
- The minimum coding standards were selected from standards that apply to all new Web sites developed after summer 2003 for the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's (EERE), as well as from Section 508 of the Americans with Disabilities Act (ADA). Where applicable, links to relevant sections of the EERE Communications Standards Web site are provided for further information . Where applicable, those standards that are part of section 508 have also been noted ; for more information about section 508: <http://www.section508.gov/>.

## Common Elements

- Provide a text or graphical link to Solar Decathlon's home page on your home page in either the header or the footer.
- At a minimum, provide an e-mail contact to your Webmaster as a graphical or text link on the home page of your site. 
- Footers on both home and second-level pages link properly
- Left navigation, if used, links correctly; on and off states work correctly and can be skipped by screen readers 
- Each page has a meaningful and unique <title> tag and uses EERE style. 

## Page Layout

- Pages displays correctly (e.g. no horizontal scrolling required to view full width of page) in a standard browser set (i.e. Internet Explorer version 5 and higher for PC and Macintosh, Netscape version 7 and higher for PC) at an 800 x 600 resolution.
- Page information conveyed with color is also available without color, and foreground and background colors provide sufficient contrast.  
- Every page contains a header consistent with its related pages and standards within a site.

## Directories and Files

- File names do not contain upper-case letters, spaces, or special characters (e.g., & or \$)
- HTML file names end in .html or .shtml, but not .htm
- All extraneous, non-linked files have been deleted

## **HTML Syntax**

- HTML syntax follows HTML 4.01 transitional standards and has been validated by the [W3C Validator](#). **i**
- All non-empty elements are nested and closed properly. **i**
- Provide row and column headings for all data tables. **508** **i**
- Images do not flicker with a frequency of greater than 2 Hz or lower than 55 Hz. **508** **i**

## **Links**

- All links work throughout the site.
- Colors for hypertext links are consistent throughout the site.
- Links are coded relatively within the site. **i**
- Anchor links are used to skip repetitive navigation links on all secondary header, footer, and other navigation. **508** **i**

## **Scripts/Applets/Dynamic Pages (CGI, JavaScript, Java etc.)**

- Every script works correctly in the standard browser set (i.e. Internet Explorer version 5 and higher for PC and Macintosh, Netscape version 7 and higher for the PC). **i**
- Content produced by scripting languages is accessible or has an accessible alternative. **508** **i**
- Pages requiring applets or plug-ins must provide a link to an accessible page where they can be downloaded. **508** **i**
- If a timed response is required, the user can request more time to complete an operation. **508** **i**
- Back button functionality is not impaired.

## **Forms**




- Forms include text labels that correspond with form controls and markup to associate the two. **508** **i**

## **Graphics**



- All images are stored in a subdirectory named 'images'
- Graphics have meaningful "alt" tags (use empty alt tags for spacer gifs and other unimportant graphics) **508** **i**
- Only client-side (rather than server-side) image maps are used **508** **i**
- Alt descriptions are used with all client side image maps. **508** **i**



## **Multimedia**

- All
  - All multimedia files are stored in and referenced from a separate subdirectory
  - Equivalent alternatives are provided for all multimedia **508** 
  - Pages requiring an applet or plug-in must provide a link to an accessible page where they the applet or plug-in can be downloaded. **508** 
- QuickTime VR
  - All QuickTime VR's will scroll correctly
  - All QuickTime hotspots will work and go to the correct location.
- Flash
  - Animation has been tested on a browser without a plug-in downloaded (ensure download process flows smoothly, and that the animation works when loaded)
  - Check all links within Flash animation. If the user exits Flash animation early, ensure that they will go to an appropriate page.
  - Sound works correctly
  - If Flash is on home page, there is an option provided to skip it
  - Non-home page animations use an interim page to determine if a visitor has a Flash plug-in. If not, they are directed to a download plug-in page or a non-Flash alternative
  - Provide an accessible equivalent to the flash animation. **508** 

## **Documents for Downloading and Printing**

- PDFs
  - All PDFs are stored and referenced from a sub-directory labeled "pdfs"
  - References to PDFs within the HTML document use a consistent format and link scheme throughout the site (e.g. [Title PDF 54 KB]) 
  - Every page with a PDF link must also include a link to Adobe's accessible download page:  
<http://www.adobe.com/products/acrobat/alternate.html> **508** 

- Native file formats
  - Approved native file formats:
    - Microsoft Word (.doc), Excel (.xls), and PowerPoint (.ppt)
    - Corel WordPerfect (.wpd)
    - PC executable files (.exe) and archived files (.zip)
    - Macintosh archived files (.hqx, .bin, .sit, .sea)
  - Native file format documents are placed in a separate subdirectory such as a "docs" subdirectory
  - References to native files within the HTML document will use the following format and link scheme throughout the site:  
Title of Document (Software 54 KB). Examples:
    - The Value of Renewables (MSWord 54 KB)
    - The Value of Renewables (Excel 54 KB)
    - The Value of Renewables (PowerPoint 54 KB)

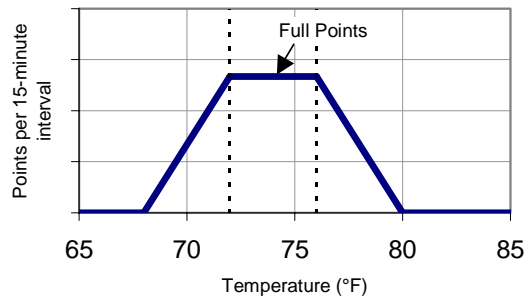
### **Testing**

- For Quality-Control Testing, test the site in the standard browser set (i.e. Internet Explorer version 5 and higher for PC and Macintosh, Netscape version 7 and higher for the PC). 

## Contest 5: Comfort Zone

### ***Temperature Control (40 pts):***

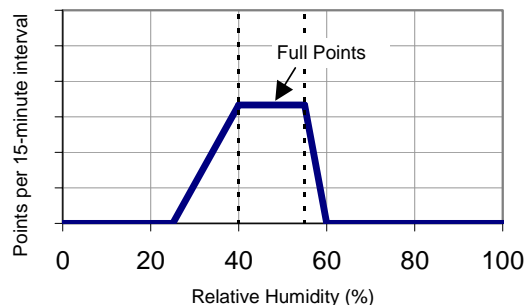
Teams earn the maximum number of points per scored 15-minute interval by keeping the time-averaged interior dry-bulb temperature between 72.0°F (22.2 °C) and 76.0°F (24.4 °C). A reduced point value is added to the team's score for every scored 15-minute interval that the time-averaged interior dry-bulb temperature is between 68.0°F (20.0 °C) and 72.0°F (22.2 °C) or between 76.0°F (24.4 °C) and 80.0°F (26.7 °C). Reduced point values are scaled linearly, as shown in the graph below. The number of points possible per 15-minute interval is not indicated on the y-axis of the graph. Teams can earn a total of 40 points for this Contest Activity, but the number of points per interval cannot be calculated until the total number of 15-minute intervals is known. Scoring will be suspended during hours that the houses will be open to the public for tours, so the total number of 15-minute intervals and the number of points per interval will be determined when the exact hours for public tours have been determined.



Full Points:	72 °F ( 22 °C ) ≤ Temperature ≤ 76 °F ( 24 °C )
Reduced Points:	68 °F ( 20 °C ) < Temperature < 72 °F ( 22 °C )
	or 76 °F ( 24 °C ) < Temperature < 80 °F ( 27 °C )
No Points:	Temperature ≤ 68 °F ( 20 °C )
	or Temperature ≥ 80 °F ( 27 °C )

### ***Humidity Control (20 pts):***

Teams earn a maximum number of points per scored 15-minute interval by keeping the time-averaged interior relative humidity between 40.0 % and 55.0%. A reduced point value is added to the team's score for every scored 15-minute interval the time-averaged interior relative humidity is between 25.0% and 40.0% or between 55.0% and 60.0%. Reduced point values are scaled linearly, as shown in the following graph. The number of points possible per 15-minute interval is not indicated on the y-axis of the graph. Teams can earn a total of 20 points for this Contest Activity. The total number of 15-minute intervals and the number of points per interval will be determined when the exact hours for public tours have been determined.



Full Points:	40 %	≤	Humidity	≤	55 %		
Reduced Points:	25 %	<	Humidity	<	40 %		
	or		55 %	<	Humidity	<	60 %
No Points:			Humidity	≤	25 %		
	or		Humidity	≥	60 %		

### ***Introduction to Comprehensive Assessment of Indoor Environmental Quality***

Conditions within a building are comfortable when all aspects of indoor environmental quality (IEQ) are addressed. The U.S. Green Buildings Council (USGBC) defines IEQ as “issues related to indoor air quality (IAQ)” and other matters, including “daylighting and lighting quality, thermal comfort, acoustics, occupant control of building systems, and access to views” (*LEED-NC Version 2.1 Reference Guide*, page 239). The USGBC LEED rating systems further address the following measures for providing good IEQ:

- Protect occupants from pollutants and high CO<sub>2</sub> levels.
- Provide for effective delivery and mixing of fresh air.
- Prevent IAQ problems resulting from the construction or renovation processes.
- Reduce the quantity of indoor air contaminants that are odorous, potentially irritating, and/or harmful to the comfort and well being of installers and occupants.
- Avoid exposing building occupants to potentially hazardous chemicals that adversely impact IAQ.
- Provide a high level of thermal, ventilation, and lighting system control by occupants.
- Provide a thermally comfortable environment.
- Provide a connection for the building’s occupants between indoor spaces and the outdoors by introducing daylight and views.

The IEQ Panel of Judges will consider the IEQ aspects outlined by the USGBC that are related to thermal comfort and IAQ and are applicable to the Solar Decathlon houses. The LEED-NC Version 2.1 criteria principally apply to commercial building construction. The Panel will consider only those aspects that are applicable to both commercial *and* residential building construction. The Lighting Panel of Judges will evaluate those aspects related to lighting quality, daylighting, and views (see [Contest 8: Lighting](#)).

*Note: The IEQ Engineering Panel will assume that the houses have been designed for Washington, D.C.’s climate.*

***Comprehensive Assessment of Thermal Comfort (20 pts):***

“Thermal comfort is that condition of mind, which expresses satisfaction with the thermal environment” (*ASHRAE Standard 55*). Individuals judge comfort through a “cognitive process involving inputs influenced by physical, physiological, psychological, and other processes” (*2001 ASHRAE Handbook of Fundamentals*, page 8.1). An individual’s metabolic rate/physical activity and clothing combined with the air temperature, mean radiant temperature, air velocity, and air humidity are all factors that determine that individual’s perceived thermal comfort.

The IEQ Panel of Judges will evaluate thermal comfort according to the following criteria:

- Thermally comfortable conditions are achieved by integrating technologically and/or economically innovative, low-energy strategies with minimal distractions to the occupant (e.g., avoiding excessive air movement and noise).
- Control of thermal comfort systems is user-friendly and responsive to the user’s desires.
- Uniform thermal conditions exist throughout the house.
- Convincing evidence is presented demonstrating that comfortable thermal conditions will be maintained during all times of the day and year.

***Comprehensive Assessment of Indoor Air Quality (20 pts):***

Sources releasing gasses and particulates into the indoor environment are “the primary cause of indoor air quality problems in homes,” according to the U.S. Environmental Protection Agency (EPA) (<http://www.epa.gov/iaq/pubs/insidest.html#Intro>). These sources include building materials, occupant activities, HVAC system control and effectiveness, combustion devices or activities within the house, and other introduced pollutants. The health effects of IAQ issues on occupants could be immediate, could occur years after exposure, or might not occur at all.

The IEQ Panel of Judges will evaluate indoor air quality (IAQ) according to the following criteria:

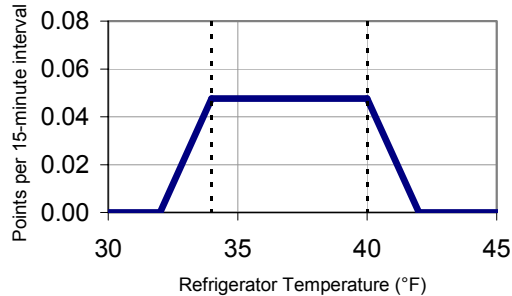
- Excellent IAQ is achieved by integrating technologically and/or economically innovative, low-energy strategies with minimal distractions to the occupant (e.g., avoiding excessive air movement, noise, and odors).
- Control of IAQ systems is user-friendly and responsive to the user’s desires.
- Strategies for maintaining excellent IAQ effectively minimize pollutant sources.
- Convincing evidence is presented demonstrating that good IAQ conditions will be maintained during all times of the day and year.

<b>Contest Activity</b>	<b>Points Available</b>
Temperature Control	40
Humidity Control	20
Comprehensive Assessment of Thermal Comfort	20
Comprehensive Assessment of Indoor Air Quality	20
<b>TOTAL</b>	<b>100</b>

## Contest 6: Appliances

### **Refrigeration Temperature Control (20 pts):**

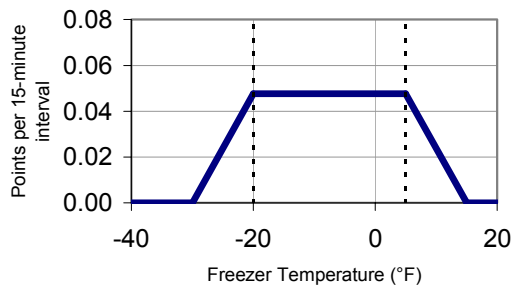
Teams earn a maximum number of points per scored 15-minute interval by keeping the time-averaged interior refrigerator temperature between 34.0°F (1.11 °C) and 40.0°F (4.44 °C). A reduced point value is added to the team's score for every scored 15-minute interval in which the time-averaged interior refrigerator temperature is between 32.0°F (0.00 °C) and 34.0°F (1.11 °C) or between 40.0°F (4.44 °C) and 42.0°F (5.56 °C). Reduced point values are scaled linearly, as shown in the graph below.



Maximum points per 15-minute interval:		0.0476 points	
Full Points:	34 °F ( 1.1 °C ) ≤ Temperature ≤	40 °F ( 4.4 °C )	
Reduced Points:	32 °F ( 0.0 °C ) < Temperature <	34 °F ( 1.1 °C )	
	or	40 °F ( 4.4 °C ) < Temperature <	42 °F ( 5.6 °C )
No Points:	Temperature ≤ 32 °F ( 0.0 °C )		
	or		Temperature ≥ 42 °F ( 5.6 °C )

### **Freezer Temperature Control (20 pts):**

Teams earn a maximum number of points per scored 15-minute interval by keeping the time-averaged interior freezer temperature between -20.0°F (-28.9 °C) and 5.0°F (-15.0 °C). A reduced point value is added to the team's score for every scored 15-minute interval the time-averaged interior freezer temperature is between -30.0°F (-34.4 °C) and -20.0°F (-28.9 °C) or between 5.0°F (-15.0 °C) and 15.0°F (-9.44 °C). Reduced point values are scaled linearly, as shown in the graph below.



Maximum points per 15-minute interval:		0.0476 points	
Full Points:	-20 °F ( -29 °C ) ≤ Temperature ≤	5 °F ( -15 °C )	
Reduced Points:	-30 °F ( -34 °C ) < Temperature <	-20 °F ( -29 °C )	
	or	5 °F ( -15 °C ) < Temperature <	15 °F ( -9.4 °C )
No Points:	Temperature ≤ -30 °F ( -34 °C )		
	or		Temperature ≥ 15 °F ( -9.4 °C )

***Clothes Washing Tasks (15 pts):***

Teams may earn 7.5 points per day on two days of the Contest Week by washing 12 towels provided by the Organizers. An automatic clothes washer approved by the Organizers must complete a normal factory-set, automatic cycle without intervention during the cycle. The water temperature must reach 110 °F (43.3°C) at some point during the cycle to earn the points.

***Clothes Drying Tasks (15 pts):***

After performing the clothes washing tasks on two days of Contest Week, teams may earn 7.5 points per day by drying the 12 towels provided by the Decathlon organizers to a weight less than or equal to the towels' original weight. A 6-hour time period will be defined, during which the towels must be collected, washed, dried, and returned. The drying method may include active drying (e.g., machine-dry), passive drying, (e.g., on a clothes line), or any combination of active or passive drying. All drying methods that require the towels to be visible must be demonstrated to the Architecture Jury and Dwelling Panel of Judges as they tour the houses.

***Dishwashing Tasks (10 pts):***

Teams may earn 2 points per day 5 days of the Contest Week by running an automatic dishwasher approved by the Organizers through a complete, approved, factory-set, automatic washing cycle without intervention during the cycle. The temperature of a dish placed in the dishwasher must reach 115°F (46.1 °C) at some point during the cycle.

***Cooking Tasks (10 pts):***

Teams will be required to cook dinners for six people for 4 days of the Contest week. Successfully completed dinners will receive 2.5 points each. At a minimum, kitchens must include a cooktop and oven to complete cooking tasks.

***TV/Video Operation (5 pts):***

Teams may earn 1 point per day for 5 days of the Contest Week by showing a video on a TV monitor continuously from 10 a.m. to 4 p.m.

***Computer Operation (5 pts):***

Teams may earn 1 point per day for 5 days of the Contest Week for operating their computer and monitor continuously from 9 a.m. to 5 p.m. The computer and monitor may enter low-energy mode at any time.



<b>Contest Activity</b>	<b>Points Available</b>
Refrigeration Temperature Control	20
Freezer Temperature Control	20
Clothes Washing Tasks	15
Clothes Drying Tasks	15
Dishwashing Tasks	10
Cooking Tasks	10
TV/Video Operation	5
Computer Operation	5
<b>TOTAL</b>	<b>100</b>

#### Summary of Revisions

November 2, 2004

- Added link to *Cooking Task (Contest 6 Details)*.

## Cooking Task (Contest 6 Details)

During the competition, teams can receive up to 10 points for this Contest Activity. Each team will be required to cook an evening meal for a minimum of six people (including one Organizer) on each of 4 days (Monday through Thursday) of the Contest Week. Successfully completed meals will receive 2.5 points each.

Teams are required to submit meal plans to the Organizers in accordance with these rules. Table 1 contains a sample meal plan. One electronic copy (Microsoft Word document or Adobe PDF) of the meal plan must be submitted to Mike Wassmer at [michael\\_wassmer@nrel.gov](mailto:michael_wassmer@nrel.gov) on or before August 9, 2005. To be considered “on time,” meal plans must arrive at their intended destination by 5 p.m. (mountain time) on the due date. The Organizers will review the meal plans for compliance.

### Appliances

As stated in the [Contest 6: Appliances](#) document, each team’s kitchen must include a cooktop, an oven, a refrigerator, and a freezer. Examples of oven types include a microwave, conventional, or convection oven. The purchase of appliances and necessary storage, preparation, and serving equipment (e.g., plates, utensils, pots and pans) is each team’s responsibility. Teams also have the option of using other small appliances such as blenders and food processors to aid in the preparation of meals, but to receive credit for this Contest Activity, each team must use the cooktop, oven, refrigerator, and freezer in their house to prepare the components of required meals.

### Safety Requirements

The following safety requirements must be met to receive points in this Contest Activity:

- To comply with National Park Service rules, no food may be served to the general public.
- No alcoholic beverages may be stored, used in meal preparation, served, or used in a meal in any way.
- No raw eggs, raw meats, or raw fish may be stored, prepared, served, or used in a meal in any way.
- All water used for cooking and drinking shall be drinking water purchased in sealed containers. The use of the house’s main water supply system is not permitted for these applications.
- If the requirements of the dishwashing tasks for [Contest 6: Appliances](#) are not met, meals must be prepared and served using equipment (e.g., cups, glasses, plates, utensils, pots and pans) that has been sterilized or that is disposable.
- Normal domestic wastewater may go into the wastewater tank. Hazardous or toxic chemicals are not allowed in the wastewater tank.
- All frozen beverages and foods must be stored in the freezer until preparation for serving.
- All beverages and food must be stored properly and according to the instructions on the packaging. For example, beverages and foods marked “refrigerate after opening” must be refrigerated appropriately after opening.

- Pre-cooked, pre-packaged, factory-sealed items (e.g., canned, frozen, and pre-packaged, pre-cooked, factory-sealed meats) are allowed provided they are stored and prepared according to the guidelines at the Center for Food Safety and Applied Nutrition (CFSAN) and the Food and Drug Administration's (FDA) Web site at <http://www.cfsan.fda.gov/~dms/fttcook.html>. Take-out and over-the-counter delicatessen food items will not be permitted because they are not pre-packaged and factory-sealed.
- When planning meals, please consider that the people you will be feeding might have food allergies. Common food allergies are: milk/dairy products, eggs, peanuts, tree nuts (walnut, cashew, pecans, etc.), fish, shellfish, soy, and wheat. To help prevent allergic reaction, the Organizers recommend that the teams create a list of ingredients for each of the items being served at each meal.

## Contest Activity Requirements

- Meals shall be served between 5:30 p.m. and 7:00 p.m. on Monday through Thursday of Contest Week.
- An Observer will make note of preparations for the meals to help the Contest Official determine compliance with the rules of this Contest Activity.
- The meals must be prepared and cooked in the team's house within the 800-ft<sup>2</sup> footprint.
- Each meal must consist of the following four components: main course, side dish (served with, but subordinate to, the main course), dessert, and beverage. Of the four components, one must be served hot or heated using the cooktop, one must be served hot or heated using the oven, one must be served chilled using the refrigerator, and one must be served frozen using the freezer. Room temperature components will not satisfy cooking task requirements. Each team must use the cooktop, oven, refrigerator, and freezer in its house for each meal prepared. See Table 2 for examples of meal components that fall within these preparation categories.
- Meal components must be prepared and served appropriately. For example, frozen pizza must be baked before serving.
- A hot item (oven or cooktop) is prepared with boiling water or has an internal temperature of 165°F (73.9°C). For example, the water to prepare a main course such as pasta must have boiled. To determine cooking task compliance, an Observer or Organizer will verify visually that all hot items requiring boiling water have been prepared with boiling water. If serving pre-cooked, pre-packaged, and factory-sealed, or canned items, the internal temperature of the food must have reached 165°F (73.9°C). (See CFSAN/FDA's Web site at <http://www.cfsan.fda.gov/~dms/fttcook.html> for clarification.) To determine cooking task compliance, an Observer or Organizer will verify with a thermometer that all hot items requiring a minimum temperature of 165°F (73.9°C) have reached that temperature.
- Heated items (oven or cooktop) shall be heated to a temperature above ambient and will be evaluated tactilely and visually.
- Chilled items (prepared using and/or stored in the refrigerator) and frozen items (prepared using and/or stored in the freezer) will be evaluated tactilely and visually.
- Main course items may not be served for credit more than once during Contest Week. For example, pizza or a variation of pizza may not be served multiple times.
- Each team will be required to provide a total of six servings of each meal component (main course, side dish, dessert, and beverage) at each meal. Each of the six people at each meal will receive one serving of each component. For serving sizes, see Table 3.

- Some meal-planning clarifications:
  - Hot beverages, such as hot tea, do qualify as a cook-top-prepared beverage.
  - A meal consisting of, for example, a cook-top-prepared main course, a chilled side dish, a freezer-prepared dessert, and a cook-top-prepared beverage, will not get credit, because the oven was not used to prepare at least one of the meal components.
  - A meal consisting of, for example, a main dish that required the use of both the cooktop and the oven, a frozen dessert, and a chilled beverage will not get credit, because, even though it uses all four required appliances, it does not include all of the four required meal components (no side dish).
  - Provided teams meet all cooking task requirements, they are permitted to prepare a meal with more than four components. Teams should indicate in their submitted meal plans which four components should be considered for compliance with the task.

## Additional Information

**Table 1. Sample Meal Plan**

<b>Meal #1</b>	<b>Meal #2</b>
Main Course: Tuna casserole (oven/ hot)	Main Course: Pizza (oven/ hot)
Side Dish: Green salad with dressing (refrigerator/ chilled)	Side Dish: Broccoli (cooktop/ hot)
Dessert: Ice cream pie (freezer/ frozen)	Beverage: Soda (refrigerator/ chilled)
Beverage: Fresh brewed tea (cooktop/ hot)	Dessert: Popsicles (freezer/ frozen)
<b>Meal #3</b>	<b>Meal #4</b>
Main Course: Ham (purchased pre-cooked, pre-packaged, and factory sealed) (oven/ heated)	Main Course: Canned vegetarian chili (cooktop/ heated)
Side Dish: Potatoes (cooktop/ hot)	Side Dish: Corn Bread (oven/ hot)
Optional second Side Dish: Raw vegetables with dip (refrigerator/ chilled)	Optional second Side Dish: Fruit salad (refrigerator/ chilled)
Dessert: Sherbet (freezer/ frozen)	Dessert: Ice cream (freezer/ frozen)
Beverage: Soda (refrigerator/ chilled)	Beverage: Soda (refrigerator/ chilled)

**Table 2. Example Meal Components within Preparation Categories**

<b>Cooktop</b> (Hot and heated items)	<b>Oven Cooked</b> (Hot and heated items)	<b>Refrigerator</b> (Chilled)	<b>Freezer</b> (Frozen)
Coffee, tea, hot chocolate	Baked goods (cookies, cakes, brownies, pies)	Pre-cooked, pre-packaged and factory-sealed cold cuts	Frozen yogurt
Pasta	Casseroles	Dairy products	Ice cream
Potatoes	Pasta	Fruit or fruit salad	Pie
Pre-cooked, pre-packaged, and factory-sealed, or canned items	Pizza	Green salad	Popsicles
Rice	Potatoes	Jell-O	Sherbet
Soup, chili, stew or sauce	Pre-cooked, pre-packaged and factory-sealed or canned items	Juice	Sorbets
Cooked vegetables	Rice	Pasta	
	Vegetables	Pudding	
		Soda	
		Vegetables	

**Table 3. What Counts as a Serving?**

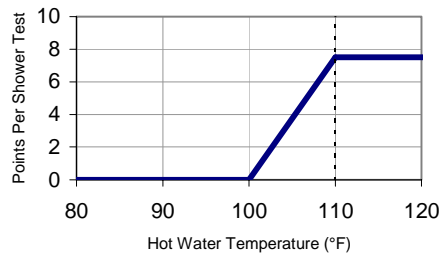
<b>Bread, Cereal, Rice, Pasta</b>		
1 slice of bread	½ cup of cereal, cooked rice, cooked pasta	
<b>Vegetable</b>		
1 cup of raw, leafy vegetables	½ cup of other vegetables—cooked or chopped raw	¾ cup of vegetable juice
<b>Fruit</b>		
1 medium apple, banana, orange	½ cup of chopped, cooked, or canned fruit	¾ cup of fruit juice
<b>Milk, Yogurt, Cheese</b>		
1 cup of milk, yogurt	1 ½ ounces of natural cheese	2 ounces processed cheese
<b>Meat, Poultry, Fish, Dry Beans, Eggs, Nuts</b>		
2 – 3 ounces of cooked, lean meat, poultry, or fish	½ cup of cooked dry beans or 1 egg count as 1 ounce of lean meat. 2 tablespoons of peanut butter or ⅓ cup of nuts count as 1 ounce of meat	

Source: Adapted from the U.S. Federal Citizen Information Center's "Food Guide Pyramid." The publication is available electronically at [http://www.pueblo.gsa.gov/cic\\_text/food/food-pyramid/main.htm](http://www.pueblo.gsa.gov/cic_text/food/food-pyramid/main.htm).

## Contest 7: Hot Water

### ***Shower Tests (75 pts):***

Each day during the Contest Week, two “shower tests” will be performed. There will be one shower test in the morning and one in the afternoon, for a total of 10 shower tests during the Contest Week. Teams may earn up to 7.5 points for each successful shower test. For each test, the team must deliver at least 15 gallons (U.S.) (56.8 liters) of hot water in no more than 10 minutes to qualify for points. Maximum points are earned by delivering an average temperature of at least 110°F (43.3 °C). An average temperature below 100°F (37.8 °C) earns no points. For temperatures between 100°F (37.8 °C) and 110°F (43.3 °C), the number of points is scaled linearly, as shown in the graph below.



Maximum points per shower test:		7.5000 points
Full Points:	Temperature ≥	110 °F ( 43.3 °C )
Reduced Points:	100 °F ( 37.8 °C ) < Temperature <	110 °F ( 43.3 °C )
No Points:	Temperature ≤	100 °F ( 37.8 °C )

### ***Comprehensive Assessment of Hot Water System (25 pts):***

The Hot Water Panel of Judges will evaluate the following aspects of the hot water system that are not evaluated by the shower tests:

- Design and implementation of technologically or economically (or both) innovative ideas
- Ability of the system to efficiently meet typical hot water loads throughout the year in the Washington, D.C., climate
- Intelligent integration and proper sizing of the system components
- Ability of the system to efficiently meet greater than usual loads when guests are present or water use is unusually high for a short period of time
- Use of energy-efficient collection, storage, and delivery strategies
- Frequency and ease of required maintenance
- Noise generation
- Ability to deliver hot water immediately to a load without a warm-up period

*Note: The term “hot water system” may include but is not limited to the following components: collector (or other water heating device), storage, distribution, controls, and fixtures.*

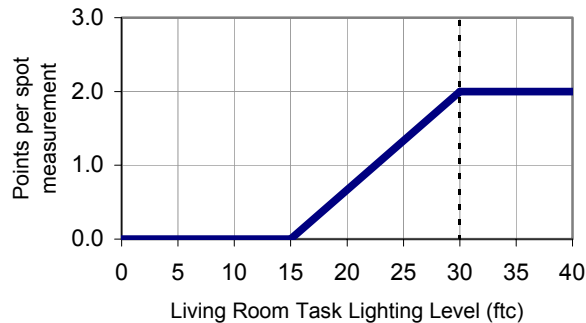
<b>Contest Activity</b>	<b>Points Available</b>
Shower Tests	75
Comprehensive Assessment of Hot Water System	25
<b>TOTAL</b>	<b>100</b>



## Contest 8: Lighting

### *Electric Lighting Quantity (20 pts):*

On one evening near the beginning of the Contest Week, after the sun has set, the Contest Officials will take measurements of lighting levels in each room of a team's house. As illustrated in the figures below, full points are awarded at or above the desired lighting level, and no points are awarded below the minimum lighting level. Points for lighting levels between the minimum and desired levels are scaled linearly. All measurements are in units of footcandles (ftc). Light-emitting devices cannot be within 18 in. (45.7 cm) of the sensors. Contest Officials will photograph the lighting system configuration used in this Contest to ensure that the same configuration is used in the Electric Lighting Quality contest.



Maximum points per spot measurement:

2.0 points

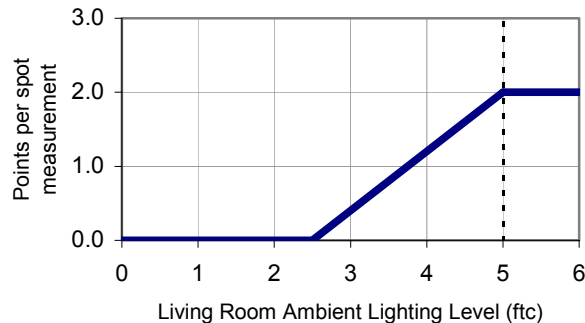
Full Points:

Light Level  $\geq$  30 ftc ( 323 lux )

Reduced Points: 15 ftc ( 161 lux ) < Light Level < 30 ftc ( 323 lux )

No Points:

Light Level  $\leq$  15 ftc ( 161 lux )



Maximum points per spot measurement:

2.0 points

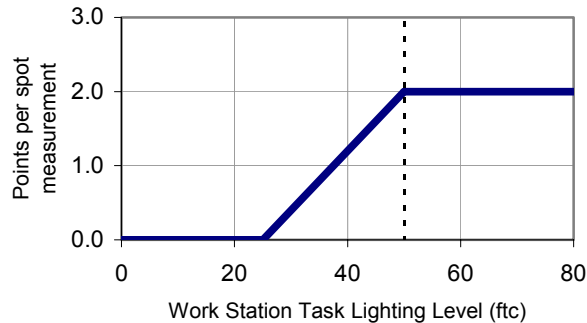
Full Points:

Light Level  $\geq$  5 ftc ( 54 lux )

Reduced Points: 2.5 ftc ( 27 lux ) < Light Level < 5 ftc ( 54 lux )

No Points:

Light Level  $\leq$  2.5 ftc ( 27 lux )



Maximum points per spot measurement:

2.0 points

Full Points:

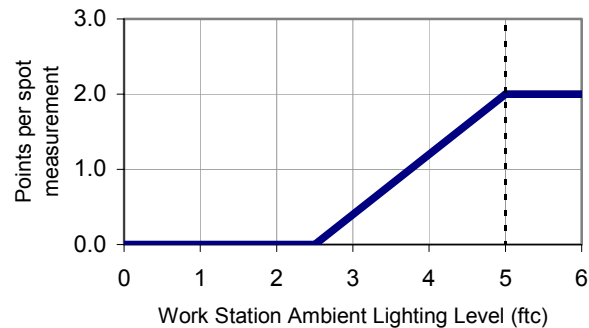
Light Level  $\geq$  50 ftc ( 538 lux )

Reduced Points:

25 ftc ( 269 lux ) < Light Level < 50 ftc ( 538 lux )

No Points:

Light Level  $\leq$  25 ftc ( 269 lux )



Maximum points per spot measurement:

2.0 points

Full Points:

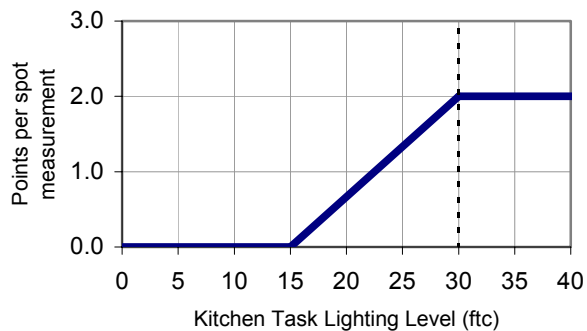
Light Level  $\geq$  5 ftc ( 54 lux )

Reduced Points:

2.5 ftc ( 27 lux ) < Light Level < 5 ftc ( 54 lux )

No Points:

Light Level  $\leq$  3 ftc ( 27 lux )



Maximum points per spot measurement:

2.0 points

Full Points:

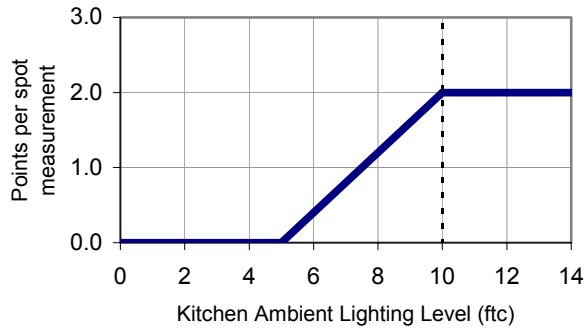
Light Level  $\geq$  30 ftc ( 323 lux )

Reduced Points:

15 ftc ( 161 lux ) < Light Level < 30 ftc ( 323 lux )

No Points:

Light Level  $\leq$  15 ftc ( 161 lux )



Maximum points per spot measurement:

2.0 points

Full Points:

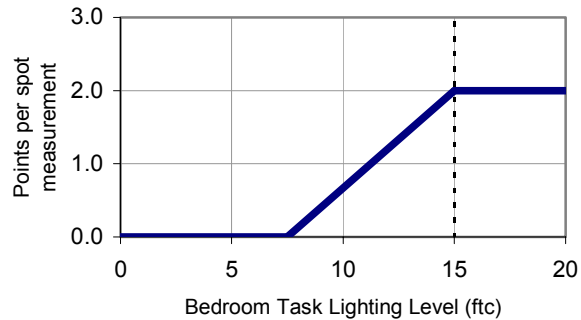
Light Level  $\geq$  10 ftc ( 108 lux )

Reduced Points:

5 ftc ( 54 lux ) < Light Level < 10 ftc ( 108 lux )

No Points:

Light Level  $\leq$  5 ftc ( 54 lux )



Maximum points per spot measurement:

2.0 points

Full Points:

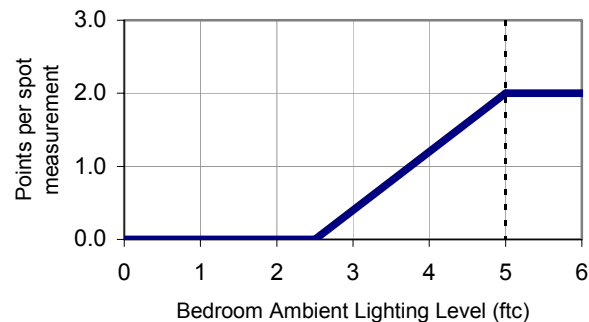
Light Level  $\geq$  15 ftc ( 161 lux )

Reduced Points:

7.5 ftc ( 81 lux ) < Light Level < 15 ftc ( 161 lux )

No Points:

Light Level  $\leq$  8 ftc ( 81 lux )



Maximum points per spot measurement:

2.0 points

Full Points:

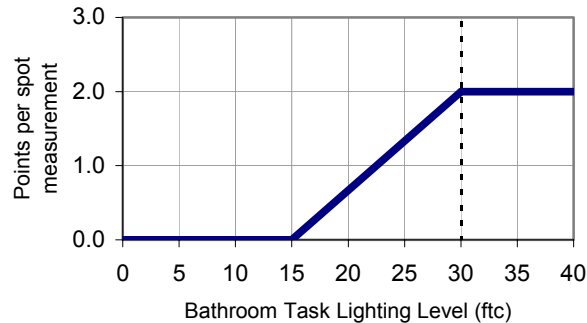
Light Level  $\geq$  5 ftc ( 54 lux )

Reduced Points:

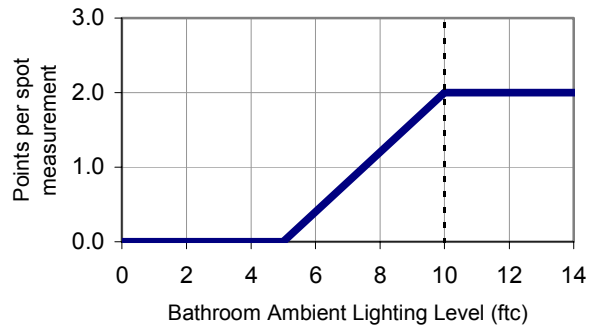
2.5 ftc ( 27 lux ) < Light Level < 5 ftc ( 54 lux )

No Points:

Light Level  $\leq$  3 ftc ( 27 lux )



Maximum points per spot measurement:	2.0 points
Full Points:	Light Level $\geq$ 30 ftc ( 323 lux )
Reduced Points:	15 ftc ( 161 lux ) < Light Level < 30 ftc ( 323 lux )
No Points:	Light Level $\leq$ 15 ftc ( 161 lux )

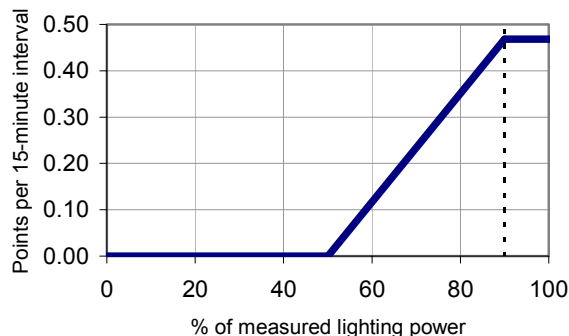


Maximum points per spot measurement:	2.0 points
Full Points:	Light Level $\geq$ 10 ftc ( 108 lux )
Reduced Points:	5 ftc ( 54 lux ) < Light Level < 10 ftc ( 108 lux )
No Points:	Light Level $\leq$ 5 ftc ( 54 lux )

### ***Standard Usage Patterns (15 pts):***

Points are available 4 days of the Contest Week for providing interior lighting in the evening. The task and ambient light levels measured in the electric lighting quantity Contest Activity must be maintained from 7:30 p.m. to 9:30 p.m. The organizers will use power measurements, not light level measurements, to ensure that this lighting schedule is met. During the electric lighting quantity Contest Activity, the total power consumed by all the lamps in use to attempt to meet or exceed the required light levels will be measured. During the hours specified above, teams could earn points every 15 minutes for consuming all or most of the power consumed during the electric lighting Quantity Contest Activity according to the following graph.

*Note: The electric lighting system must be located on a dedicated circuit(s) to make this power measurement possible. If the lighting system is not located on a dedicated circuit(s), no points will be awarded for this Contest Activity.*



Maximum points per 15-minute interval: 0.4688 points

Full Points: % measured  $\geq$  90 %

Reduced Points: 50 % < % measured < 90 %

No Points: % measured  $\leq$  50 %

### ***Exterior Lighting (5 pts):***

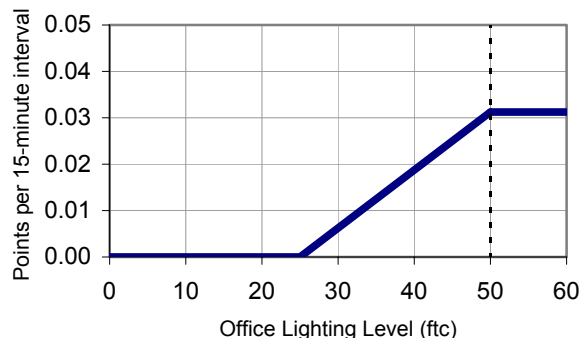
Points will be awarded for providing appropriate exterior lighting according to the following requirements:

- The exterior house number light must be on from 8 p.m. to 6 a.m. of the following day. Contest Officials will perform periodic spot checks throughout the night to verify that the house number is illuminated, and 0.625 points will be awarded for each of 4 nights of the Contest Week that a house passes all the spot checks. If a house fails at least one spot check, no points will be awarded for that night.
- The exterior door lights must be energized from 8 p.m. to 6 a.m. of the following day. Contest Officials will perform periodic spot checks throughout the night to verify that either the lights are on continuously, or that they turn on when a motion sensor is tripped; 0.625 points will be awarded for each of 4 nights of the Contest Week that a house passes all the spot checks. If a house fails at least one spot check, no points will be awarded for that night.

### ***Integration of Electric and Natural Lighting (5 pts):***

Before the Contest Week begins, photometers (light level sensors) will be installed on the surface of the home office desk. Light-emitting devices within 18 in. (45.7 cm) of the sensors are not permitted.

Teams can earn a maximum of 0.0313 points per 15-minute interval by keeping the time-averaged office work surface light level above 50 footcandles (538 lux) between 9 a.m. and 5 p.m. for 4 days of the Contest Week. A reduced point value is added to the team's score for every 15-minute interval the time-averaged office work surface light level is between 25.0 footcandles (269 lux) and 50.0 footcandles (538 lux). Reduced point values are scaled linearly, as shown in the following graph.



Maximum points per 15-minute interval:		0.0313 points
Full Points:	Light Level $\geq$	50 ftc ( 538 lux )
Reduced Points:	25 ftc ( 269 lux ) < Light Level <	50 ftc ( 538 lux )
No Points:	Light Level $\leq$	25 ftc ( 269 lux )

### ***Electric Lighting Quality (40 pts):***

Lighting plays a significant role in the appearance and style of a home. In addition to producing the light needed to enjoy a home, lighting can create a “mood” and create highlights that feature aspects of the architecture and interior design. Very often the quality of the lighting, including both the lighting fixtures and their effect on the space, can dramatically enhance an overall feeling of quality and value.

The obvious challenge of lighting design in a solar home is to achieve these qualities using energy-efficient technologies and low-wattage light sources. In addition, providing controls that reduce the use of lighting or reduce power through dimming can save energy as well as add to the convenience of the lighting and to the ambiance it creates.

Judging the lighting quality will be conducted by a Panel of Judges consisting of professional lighting designers, interior designers, or architects (or all three), who will award points in each of the following categories:

- Appropriateness: The lighting design provides lighting that is appropriate for the space, in general according to genre and location.
- Style: The design uses luminaires that are consistent with the overall architecture and interior design in shape, form, material, finish, and other qualities.
- Performance: In addition to meeting light level requirements, the lighting produces desirable effects (such as emphasizing work areas, artwork, or architectural features), creates dramatic appearance or great ambiance (especially in the living areas of the room), and adds artistic design or flair (or all three).
- Color: The design makes proper use of color temperature (CCT) and color rendering (CRI) in each space.
- Controls: The design provides switching or dimming that is accessible to users and permits or enhances the use of lighting.

***Daylighting Quality (15 pts):***

Simply providing daylighting for interior spaces is not enough. If there is too much daylight, or daylight is introduced incorrectly into the space, overheating and glare can result and impede or prevent the enjoyment of interior spaces and the work that must be done in them. In this Contest Activity, designs will be evaluated subjectively for the qualities of the daylighting system(s) employed in the home. A Panel of Judges consisting of professional lighting designers, interior designers, or architects (or all three) will award points based on the following criteria.

- The Panel of Judges will evaluate the ability of the daylighting design to provide adequate interior illumination throughout most of the day under most seasonal and daily weather conditions. This includes the amount, type, and orientation of glazing and the use of shading devices to control glare or heat gain (or both).
- The Panel of Judges will evaluate the appearance and integration of the daylighting system into the architectural design of the home.

<b>Contest Activity</b>	<b>Points Available</b>
Electric Lighting Quantity	20
Standard Usage Patterns	15
Exterior Lighting	5
Integration of Electric and Natural Lighting	5
Electric Lighting Quality	40
Daylighting Quality	15
<b>TOTAL</b>	<b>100</b>

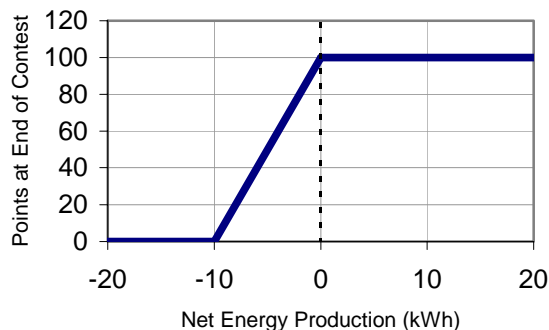
**Summary of Revisions**

November 2, 2004

- Revised Standard Usage Patterns: Light levels must be maintained until 9:30 p.m. This has been changed from 9:45 p.m.
- Revised Standard Usage Patterns: The maximum points per 15-minute interval are 0.4688 points.

## Contest 9: Energy Balance

Teams whose houses have produced a net amount of electrical energy of zero kWh or more over the course of the Contest Week will earn 100 points. Teams whose net electrical production is less than -10.0 kWh will receive zero points. Teams whose net electrical production is less than zero kWh but greater than -10.0 kWh will receive points that have been scaled linearly, as illustrated in the graph below.



Maximum points at end of contest: 100.0 points

Full Points: Net Energy  $\geq$  0 kWh

Reduced Points: -10 kWh < Net Energy < 0 kWh

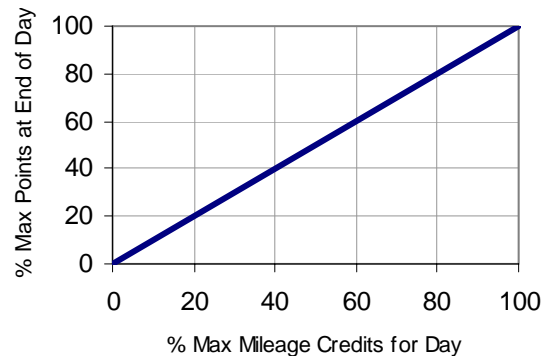
No Points: Net Energy  $\leq$  -10 kWh

Contest Activity	Points Available
Energy Balance Measurement	100
<b>TOTAL</b>	<b>100</b>



## Contest 10: Getting Around

Points will be awarded on a daily basis for mileage credits earned according to the graph below and the associated table of points. The team that accumulates the most mileage credits on each day of the Contest Week establishes the maximum mileage credits and receives all available points for that day. The other teams receive a percentage of the daily available points; the points they receive are determined by, and equal to, the percentage that they have earned of the daily maximum mileage credits. For example, if team A accumulates 50 mileage credits on day 1 and team B accumulates 40 mileage credits on day 1, team A would earn 20 points and team B would earn 16 points for day 1. Each team can select its own driving route(s). The Organizers will install a tracking device in each vehicle to monitor vehicle locations during the Contest.



Contest Activity	Points Available
Mileage Credit: Day 1	20
Mileage Credit: Day 2	20
Mileage Credit: Day 3	20
Mileage Credit: Day 4	20
Mileage Credit: Day 5	15
Mileage Credit: Day 6 and The Final Lap	5
<b>TOTAL</b>	<b>100</b>

# Battery Requirements and Guidelines

## Introduction

This supplemental document identifies and discusses codes, regulations, and best practices for battery use and installation as they relate to the Solar Decathlon. A battery system can be hazardous because it is a continuously “energized” source of electricity and contains corrosive electrolytes. Also, batteries can be heavy, can cause fires, and can produce explosive or corrosive gases. Solar Decathlon team members need to be aware of these inherent hazards to minimize the risk to themselves and the public when transporting, installing, maintaining, using, or replacing a battery. Although this document focuses on lead-acid batteries, most of the information and discussion applies to all battery chemistries.

Because this competition has a strong public outreach component, the Organizers are providing these guidelines to reinforce the importance of safety at the Event. The public viewing the Solar Decathlon homes may choose to incorporate some of the features and technologies in their own homes. Because solar-powered homes will be new to many people, the homes need to demonstrate safe photovoltaic (PV) and battery systems. Although most people are familiar with automotive batteries, the batteries in the Solar Decathlon homes will be larger, and they are subject to additional regulations and considerations.

## *General Applicability and Interpretation*

This document lists and discusses most of the codes, standards, and recommendations that apply to batteries typically used in solar-powered homes. Although the list may look exhaustive, some codes, standards, or recommendations have been left out intentionally or may have been left out inadvertently. Also, state and local jurisdictions and the sponsoring school may have additional requirements beyond the international or national codes listed here.

Interpreting the codes, regulations, and recommendations is ultimately the responsibility of the individual Solar Decathlon teams and their institutions. In this document, the Organizers have established a minimum level of battery safety consistent with published codes, regulations, and recommendations. Individual teams or their sponsoring institution may add their own additional requirements.

Battery codes, regulations, and recommendations have only a minor impact on the home’s energy usage. Batteries are emphasized here primarily because they represent an important safety issue. Teams must make safety a priority throughout the competition.

In addition to safety, proper interpretation of codes, regulations, and recommendations can improve a battery’s performance and extend its lifetime. Although the Solar Decathlon competition on the National Mall takes place over a brief period of time, a battery system should be designed, installed, and operated as if the house were to be occupied full time and the battery system lifetime needed to be maximized

through proper operation and maintenance. The public will scrutinize the Solar Decathlon homes and the schools they represent, so all battery systems must be properly installed and operated.

### ***Battery Terminology***

Commonly accepted terms will be defined to interpret the codes and to discuss the issues within the context of the Solar Decathlon Rules and Regulations and with other battery industry experts. The **cell** is the smallest electrical unit capable of producing voltage. In the lead-acid battery chemistry, the cell produces 2 V nominally. The **battery** consists of ALL the cells that are series or parallel connected.

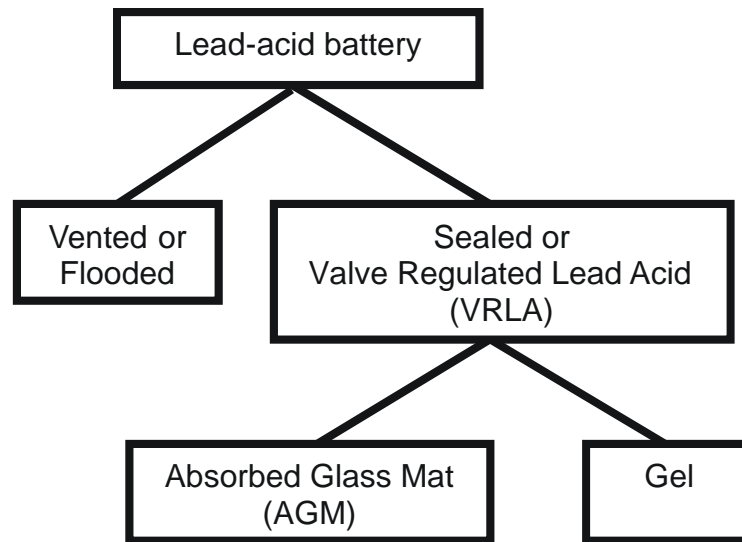
Confusion begins when referring to the home's battery. Many of the codes and standards refer to "batteries" as the collection of individual batteries that comprise a battery. This publication, when discussing the Solar Decathlon competition, regulations, and suggested best practices, will refer to the house battery as the **battery bank** or **battery system**.

**State-of-charge** (SOC) is the percent of electrical energy stored in a battery compared to the manufacturer's rated capacity of the battery. A full battery has a 100% SOC and a discharged lead-acid battery has a 20% SOC. Most batteries are not fully discharged to 0% SOC, even though the manufacturer's rated capacity is based on a full discharge. **Depth-of-discharge** (DOD) is the inverse of SOC. A fully charged battery has a 0% DOD whereas a discharged lead-acid battery has an 80% DOD.

### ***Battery Chemistries***

There are several electrochemical battery types available for solar-powered homes. The most common battery type is lead-acid because of availability and cost. Other battery types that have been used are nickel-cadmium (NiCd), nickel-iron (NiFe), nickel metal hydride (NiMH) and lithium-ion. Each battery type has its own specific operating, transportation, cleanup, and disposal requirements. The battery manufacturer should supply this information along with a Material Safety Data Sheet (MSDS). Whereas some of the discussion in this document focuses on lead-acid batteries, most of the discussion is applicable to all types of batteries.

Most of the battery chemistries can be incorporated into vented or sealed battery configurations. Figure 1 shows the different types of lead-acid batteries. The vented (or flooded) configuration contains liquid electrolyte (either acid or base). During normal operation, electrolyte or electrolyte film may be present on top of the battery case because of the venting of hydrogen gas, overcharging, or overfilling vented configuration batteries. Standard maintenance requirements for a vented battery include visually checking the electrolyte level and adding distilled water, if needed. In the vented configuration, electrolyte can spill out if the battery is tipped, or if the case becomes damaged. A vented battery should come with spark arrestor vent caps for each cell. After-market hydrogen recombinant and spark arrestor vent caps may also be available to help reduce water loss. Check with the battery manufacturer before replacing any vent caps.



**Figure 1. Different types of lead-acid batteries**

The sealed (or valve-regulated lead-acid [VRLA]) battery configuration avoids many of the vented battery configuration's disadvantages by immobilizing or minimizing the electrolyte. Absorbed glass mat (AGM) batteries are different than gel batteries, even though both are sealed lead-acid batteries. An AGM battery immobilizes the electrolyte by absorbing the electrolyte into a fiberglass mat. A gel battery immobilizes the electrolyte by adding silica gel creating a semi-solid mass.

Under normal operating conditions in a sealed battery, the hydrogen gas that is generated during charging and discharging is recombined with oxygen inside the cell. Depending on the manufacturer, sealed batteries can usually be placed in any orientation (with the battery terminals on top or on the side). Some manufacturers claim that certain orientations of their sealed battery improve battery-recharging efficiency. Check with the manufacturer before placing a battery in an orientation different than as received. Sealed batteries are generally more convenient to install and operate, even though the initial and operating costs may be higher.

### ***Battery Hazards and Risks***

A battery presents many hazards and risks—all of which can be minimized through proper design, installation, operation, maintenance, and disposal. A battery is always “energized”—there is no on/off switch. Even a battery that is “discharged” still contains a lot of energy.

The corrosive electrolyte inside the battery can cause physical injuries to the user or additional damage to the battery if the electrolyte leaks out of the case, spills from the battery in an accident, or vents to the atmosphere. A battery can be heavy and awkward. Poorly designed battery rooms with limited space can hinder safe lifting and installation (or removal) of a battery. If improperly manufactured or maintained, a battery can cause a fire. Also, a fire near the battery can be started if the wiring and connections are improper or maintained poorly.

A vented or flooded battery will produce hydrogen gas during normal operation. A vented lead-acid battery with antimony-containing lead plates will produce more hydrogen than a battery with calcium-containing lead plates. A sealed or VRLA battery should contain all gases during normal operations. However, during abnormal circumstances, excess pressure inside the sealed battery will cause the battery to vent hydrogen gas. A sealed battery contains a one-way pressure relief vent that can release excess pressure from inside the battery case if the battery is overcharged or overheated, or if there is a battery failure. The total amount of hydrogen gas that can be generated from a vented or sealed battery can be similar but depends on the total amount of electrolyte inside the battery. The rate of hydrogen evolution is a function of the SOC, battery age, and current.

In summary, the risks to be considered when installing, utilizing, and maintaining a battery bank are:

- Explosion/flammability of hydrogen gas
- Electric shock and electric current hazards
- Acidic or caustic electrolyte spills, exposure, or both
- Gravity related issues (such as battery lifting and batteries falling off racks due to seismic events).

## **Codes and Regulations**

There are several national level code organizations that regulate the use of battery systems in building applications. The codes and regulations cited here come from the National Fire Protection Association (NFPA), International Code Council (ICC), Occupational Safety & Health Administration (OSHA), and Department of Transportation (DOT).

## **Battery System Codes**

<b>Code Name</b>	<b>Relevant Section(s)</b>	<b>Location</b>	<b>Comments</b>
2002 National Electric Code (NEC)	Article 480 and Part VIII of Article 690	2002 NEC Handbook CD	Requirements for storage batteries and batteries used in PV installations
2003 International Fire Code (IFC)	Sections 608 and 609	2003 ICC Codes CD	Specific requirements for stationary lead-acid battery systems and VLRA battery systems
2003 International Mechanical Code (IMC)	Sections 502.1, 502.3, 502.4, 502.5	2003 ICC Codes CD	Ventilation requirements
OSHA Regulations	29 CFR Part 1926.441	<a href="http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&amp;p_id=10742">http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&amp;p_id=10742</a>	Not as detailed as other codes

## **Battery Shipping Regulations**

DOT classifies all electrochemical batteries as hazardous materials subject to regulation when transported in interstate commerce. Individual states generally adopt DOT regulations for intrastate commerce. All trucking companies and drivers should be familiar with the appropriate regulations for each state. Teams need to fully disclose to the driver and trucking company all potentially hazardous materials (batteries, ethylene-glycol, cleaning solvents, paints, etc.) that are being transported.

Most of the DOT regulations relevant to the Solar Decathlon are contained in Title 49 of the Federal Code of Regulations (49 CFR). The Hazardous Materials Table in 49 CFR Part 172.101 lists different types of batteries. All lead-acid batteries, both vented (flooded) and sealed (VRLA), are considered “wet batteries.” Section 49 CFR Part 173.159 describes wet batteries and their packaging requirements. Generally, loads with wet batteries need to be placarded (the diamond-shaped warning label on trucks), which requires a driver with a Commercial Drivers License (CDL) and a Hazardous Material endorsement. There are two possible placarding exceptions mentioned below.

49 CFR Part 173.159 (d) defines “nonspillable” batteries that do not require a placard if all requirements in that subsection are met. The battery manufacturer can state compliance with (d)(2) – labeling and (d)(3) – the vibration and pressure differential tests. Get a copy of the certification from the battery manufacturer. Subsection (d)(1) states, “The battery must be protected against short circuits and securely packaged.”

49 CFR Part 173.159 (e) could exempt flooded batteries from placarding if all four requirements are met. Subsection (e)(2) states, “The batteries must be loaded or braced so as to prevent damage and short circuits in transit.” Subsection (e)(3) states, “Any other material loaded in the same vehicle must be blocked, braced, or otherwise secured to prevent contact with or damage to the batteries.”

Compliance with the protecting, blocking, bracing, and preventing damage exceptions (d)(1), (e)(2), and (e)(3) in 49 CFR Part 173.159 is usually determined only after an accident. DOT inspectors will rarely give approval in advance. If there was an accident and the batteries shifted, broke, or caused a fire, the requirements probably weren’t met. The problem can cascade further. Because the exception wasn’t met, the truck should have been placarded and driven by a driver with a CDL and a Hazardous Material endorsement.

Because the Solar Decathlon homes will have a battery system and will be transported in interstate commerce, all DOT regulations are applicable. If a team hires a company to transport its home, the team must fully inform the company and driver about the weight and type of batteries and provide an MSDS. The transportation company assumes responsibility for compliance with all shipping regulations. If the team transports the home containing a battery system using its own driver, the driver (and possibly the school) assumes responsibility for meeting all DOT regulations.

Because of dynamic loading, a battery rack suitable for a stationary application will not be suitable for transportation. Teams should take special care in packing batteries for transportation. The battery system could be transported separately (from the house) and installed on site before the competition. After the competition, the battery system should be removed from the house for return transportation.

## Recommended or Best Practice Standards

The Institute of Electrical and Electronics Engineers (IEEE) publishes consensus standards on a wide variety of topics. An IEEE standard is useful because it presents best practice recommendations and reflects a consensus within the industry.

IEEE Standard	Title
450-1995	Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications
484-1996	Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications
485-1997	Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
928-1986	Recommended Criteria for Terrestrial PV Power Systems
929-2000	Recommended Practice for Utility Interface of PV Systems
937-2000	Recommended Practice for Installation and Maintenance of Lead-Acid Batteries for PV Systems
1013-2000	Recommended Practice for Sizing Lead-Acid Batteries for PV Systems
1106-1995	Recommended Practice for Maintenance, Testing and Replacement of Vented NiCd Batteries for Stationary Applications
1115-2000	Recommended Practice for Sizing NiCd Batteries for Stationary Applications
1145-1999	Recommended Practice for Installation and Maintenance of NiCd Batteries for PV Systems
1187-1996	Recommended Practice for Installation Design and Installation of VRLA Batteries for Stationary Applications
1188-1996	Recommended Practice for Maintenance, Testing, and Replacement of VRLA Batteries for Stationary Applications
1189-1996	Guide for Selection of VRLA Batteries for Stationary Applications
1374-1998	Guide for Terrestrial Photovoltaic Power System Safety
1375-1998	Guide for Protection of Stationary Battery Systems

IEEE standards written specifically for PV systems with a battery system are 928, 937, 1013, 1145, and 1374. The other standards may contain additional information that is useful for design and installation of any battery. IEEE Standard 929 is appropriate for grid-connected, utility-interactive PV systems.



## **Solar Decathlon Competition**

### ***National Park Service Requirements***

National Park Service (NPS) is asking decathlon teams to adhere to OSHA standards.

### ***Inspections***

As with all codes, ultimately the code inspectors will determine if the code is met physically or by intent. Appropriate calculations for seismic design of racks and ventilation requirements for battery systems should be submitted for approval in advance. On-site inspections before the competition will be performed to ensure that health and safety requirements are met.

### ***Performance Monitoring Requirements***

Organizers expect teams to have a single physical location where the battery bank may be monitored with a watt transducer, shunt, or similar device. All electrical layouts that have separate PV arrays serving separate battery banks are discouraged and must be approved by the Rules and Regulations Committee.

### **Discussion, Best Practices, and Suggestions**

Although not directly related to a Solar Decathlon Contest, battery system operation and maintenance, battery system locations, ventilation, enclosures, secondary containment, racks, and proper protective apparel can affect overall safety and can impact the cost of your renewable energy system over its lifetime. To help teams meet code requirements, the following provides suggestions and outlines best practices when designing, installing, maintaining, and utilizing a battery system.

### ***Battery Operation and Maintenance Considerations***

Something as mundane and easy to forget as battery maintenance can make or break the economics of your system. Pay careful attention to battery manufacturer recommendations, in terms of maintenance, to get the most out of your battery system.

The battery is the most significant element in your renewable energy power system that has variable efficiency. Depending on how well you take care of your batteries, you can realize round trip and life efficiencies that vary from as low as 20%–30% to as high as 85%–90%. Choosing the right charge/discharge strategy; selecting the correct battery system charger/charge controller; and utilizing a sound dispatch strategy for charging devices, meeting loads and auxiliary loads are all important.

## Operation

The renewable energy system designer/operator can control battery system operation to a large degree. How the designer/operator manages the battery system will have a strong affect on how well the battery system performs and how long it lasts. Proper management can also minimize safety risks.

Sometimes, it is difficult to find literature (from manufacturers, testing agencies, and academia alike) that describes exactly how to get the most out of a bank of batteries. Required parameters such as load profile, type of charging sources, resource profiles, dispatch strategy, dump load dispatch, etc., can vary from system to system. Therefore, this variability makes it difficult to understand each system well enough to optimize its battery operation strategy. There are, however, a few guidelines to keep in mind when developing your own operation strategy for your specific renewable energy system. They include:

1. Batteries reach peak round trip efficiencies when operated in the 50%–85% SOC range.
2. Batteries cannot stay too long in the 75%–90% SOC range without damage from sulfation (i.e. batteries need to be periodically fully charged, on a monthly or a quarterly basis).
3. Batteries kept at a high SOC (such as float or standby) can last a very long time. However, they will not realize much throughput in their lifetime.
4. Batteries repeatedly deeply discharged (to as low as 20% SOC) will realize a higher throughput but a shorter life (some manufacturers recommend discharging to 50% SOC to extend the battery life).
5. Manufacturers can or will often provide a curve that describes the depth of discharge/cycle life relationship. However, these curves are produced under fairly strict conditions that can be difficult to duplicate in the field. Treat these curves as a reference, not a warranty.
6. When there is a large amount of sunlight, it's probably better to run as many productive loads (pump water, chill milk, make ice) as you can to reduce the amount of energy that needs to be cycled through your battery system.
7. Avoid leaving batteries at a low SOC because batteries left at a low SOC can begin to sulfate within days.

## Maintenance

A well maintained and operated battery system can last many years. A poorly maintained and operated battery system can last a matter of weeks. Clearly, it's easier to damage a battery system than it is to maintain it well. However, here is a list of checks that can be performed (most battery maintenance guides will include at least some of these checks):

#### Monthly:

1. Visually inspect the batteries (look for corrosion, damaged or missing caps, wet/damp spots around caps, cracks or leaks, signs of heaving posts, damaged cable leads, damaged terminals or connectors).
2. Physically check for loose connections (loose connections can lead to overheating and seriously affect battery efficiency).
3. Check the temperature at the battery terminal and look for batteries that deviate (thermally) from the norm.
4. Take voltages of each battery (or cell if using 2 V cells) with and without current flowing and look for variation from the average. The cell voltage for a battery at open circuit that shows variation of as little as .15 V from the average can indicate a problem with that battery.
5. If using vented (flooded) batteries, take specific gravity measurements with the batteries at open circuit and look for any variations from the mean (a variation of as little as 0.02 can indicate a problem with that battery).
6. Also, if using vented (flooded) batteries, check fluid levels and fill as required (never allow the plates to become exposed to the air, use only distilled water, note which batteries are using more water and see if a pattern is developing, don't overfill with water, and never remove excess electrolyte solution).
7. Clean the tops of the batteries with a solution of 1/8 lb. baking soda per quart of warm water. Check with the battery manufacturer for approved detergents.

#### Quarterly: (in addition to the monthly checks)

1. Check connection resistance of inter-cell or inter-battery connectors (one step more than looking for loose connections) of 10% of the battery system.
2. Measure the temperature of a random sample of 20% of the battery system.

#### Annually: (in addition to monthly and quarterly checks)

1. Tighten all bolts to recommended torque.
2. Record all connection resistances.
3. Perform a capacity test.

Optional: Thermographic scans (if this technology is available—even a camcorder with infrared imaging can do the trick) can provide an excellent insight into connection problems between batteries or cells.

If your system is equipped with a battery monitor (E-meter, Tri-Metric, Data Acquisition System (DAS), etc.), periodically check your round trip efficiencies. A drop in efficiency doesn't necessarily mean that your whole battery bank is dead. It is more likely that a few batteries or cells within the battery bank need to be replaced or charged separately. The sooner you replace or charge a battery or cell that is pulling an entire string down, the better. Battery banks tend to experience cascade type failures. A single bad battery or cell may accept less current causing the entire battery bank to accept less current.

These guidelines are only an example, and not an exemplary, maintenance guide. For a more comprehensive and thorough manual, contact the battery manufacturer; most battery manufacturers will provide a manual. Proper operation and maintenance does not guarantee that you will not experience some sort of failure in at least one of your batteries before the battery bank reaches its maximum expected life cycle. Yet, failure to maintain your battery bank all but guarantees a shortened and inefficient life for your batteries.

### ***Good Battery System Locations***

Sometimes the placement of a battery bank is an afterthought. This is not a good idea. As mentioned previously, proper operation and maintenance of your battery bank can make the difference in the economic viability of your renewable energy system. If a battery is not in an accessible location, proper maintenance probably will not happen, or if it does, it will be a nuisance every time it is done. Also, the environment surrounding the batteries (such as ambient temperature) can have a serious impact on the expected life of the batteries (overheating of batteries is one of the principal failure modes). Finally, the distance between the batteries and the principal load (typically the inverter) is directly related to system efficiency (the closer the two are, the better).

Accessibility to the battery system increases the likelihood of its proper maintenance in a safe manner. Storing batteries in a mechanical crawl space or in an attic exposes batteries to elevated temperatures. This is probably one of the fastest methods to ruin a battery bank. A battery bank should be placed in an enclosure with a locked cover, or in a separate room with a door that can be locked.

Keep in mind the following when planning where to place batteries:

- For vented (flooded) batteries, a minimum of 18 in. is required between the top of the battery or battery post (whichever is higher) and the structure above it, to allow safe inspection and routine maintenance. For sealed or VRLA batteries, a reasonable working distance is required.
- Minimize the distance between batteries and the primary load (not only does cable become expensive if batteries are placed far from the inverter, but the induction of cables becomes a factor)
- Protect batteries from overheating and from cell-to-cell temperature variations (Don't place them in an attic or mechanical space that experiences high temperatures. Don't place them in a dark box on the south side of the house. Don't put them above or too near a heat source.)

- Protect batteries from cold and freezing. Whereas a charged battery has a low freezing point, a cold battery has less available capacity.
- Make the battery system accessible for routine inspections and maintenance.
- Don't place batteries directly below electronics. Batteries can (and vented batteries do) emit corrosive gases that are damaging to many things, especially electronics.
- Don't locate batteries where things will be inadvertently dropped on them.

## **Ventilation**

Code references for this section:

- IMC2003: Sections 502.3, 502.4, and 502.5
- IFC2003: Sections 608.5, 609.6, and 609.7

Hydrogen gas presents a fire hazard in any battery system installation regardless of battery type. Abnormal conditions, such as failure of the charge controller, may cause the PV charging current to flow unregulated into a fully charged battery system. In some cases, an individual cell on the battery fails and will act as a sink for the full battery system current. If any type of battery is overcharged, it can emit significant amounts of hydrogen. The total volume could be less in some battery types because there is less electrolyte, but the maximum rate of gas evolution can be similar. For scenarios like these, Solar Decathlon regulations require a well-designed ventilation system.

Hydrogen gas is very light and has a strong propensity to disperse. It is also highly combustible and can ignite under a relatively wide range of conditions (batteries have been known to explode even in open air). Because vented or flooded batteries emit hydrogen gas, special care should be taken to avoid its accumulation. Sealed batteries certainly can, have, and do emit hydrogen gas when something goes wrong. Therefore, all systems must ventilate, either passively or actively, directly to the outside air.

Energy consumption from a mechanical ventilation fan is a small portion of a building's total energy consumption. One measure to reduce the amount of energy used by ventilation fans is to only turn the fans on during charging and discharging of the battery bank.

With either mechanical ventilation or natural ventilation systems, the ventilation system should be designed to prevent pressure differentials on or around the building from causing hydrogen gas to accumulate in the ventilation pipe, duct, or devices.

In choosing whether to use active or passive ventilation systems, consider the following:

**Passive Ventilation:**

This type of ventilation is acceptable if the battery system room or enclosure has an exterior wall or opens to the exterior of the building. For this type of ventilation to work, vents must be placed near the ceiling and near the floor.

**Active Ventilation:**

This type of ventilation is required if the battery system room or enclosure does not have an exterior wall or exterior access. Unless a DC brushless motor is used, the fan motor must be located in outside air and must push fresh air into the battery system room or enclosure. The ventilation fan should be activated when charging or discharging the battery system but must also be fail-safe. (A DC fan that runs directly from the batteries via a normally closed relay is an acceptable form of fail-safe. An AC fan that runs off the inverter is not).

## ***Enclosures***

Code references for this section: IFC2003 Sections 608.3, 608.7, 609.4, and 609.9

Battery systems must be fully contained in enclosures or rooms that remain within the 800-ft<sup>2</sup> footprint. A battery system room will be permitted in lieu of a separate battery system enclosure if designed in accordance with IFC2003 Section 608.3 or 609.4.

A battery system enclosure is an appropriate means of separating the batteries from the rest of the electrical equipment, without building a separate room. This protects electrical equipment from battery gas emissions, minimizes the volume required to be ventilated (especially important if the electrical/battery system room does not have an exterior wall or exterior access), and prevents accidental contact with the batteries. Battery system enclosures must be constructed of acid-resistant materials (most plastics). A plastic bag draped over the tops of the batteries is not an enclosure. Whether or not an enclosure is used, all batteries should have some means of preventing accidental contact across the terminals (Plexiglas or rigid plastic covers are acceptable). The cover must be locked so access to batteries inside the enclosure is limited to the team's decathletes.

For inspection and maintenance purposes, the top of an enclosure should be at least 18 in. above the top of a battery or battery post (whichever is higher) unless the lid of the enclosure is hinged. A hinged lid on the enclosure will allow adequate access for maintenance and inspection and therefore can be in closer proximity to the top of a battery or battery post. It is recommended that the lid not touch the post or an electrical conductor under any circumstance.

## ***Secondary Containment***

Code references for this section: IFC2003 Sections 608.4 and 609.5

The purpose of secondary containment is both to capture any spills from watering vented or flooded cells as well as to capture any leaks from cracked or damaged batteries. Secondary containment systems should be sized according to IFC2003 Section 608.4 so as to capture the entire contents of at least one battery. Secondary containment systems only work when constructed of sealed, acid-resistant material. A plastic bag is not considered secondary containment.

If racks are used, secondary containment should be used on each rack level. Whereas a single pan at the lowest level may protect the environment, it does not protect the lower batteries from what goes on above.

## ***Battery System Racks and Stacking***

Code references for this section:

- NEC2002 Section 480.8
- IFC2003 Sections 608.7 and 609.9

If possible, battery system racks should be designed such that batteries are easily inspected, cleaned, and maintained. Most racks will have two levels and under certain circumstances may have three levels. As stated before, accessibility increases likelihood of proper maintenance. Keeping rack height minimized offers better accessibility. It also diminishes the likelihood of injury due to lifting batteries. For example, lifting a battery above a person's head to place it on the rack could be a dangerous situation.

Battery racks can provide an appropriate means of assembling many batteries within a smaller footprint; but care needs to be taken in the selection and design of the battery system rack. The rack levels must be spaced so as to allow easy and safe access to each battery level during routine inspection and maintenance. For vented batteries, a minimum of 18 in. is required between the top of a battery or battery post (whichever is higher) and the rack structure or ceiling above. This amount of space is required for safe inspection and maintenance. All racks containing sealed batteries must provide adequate space for access with tools to verify tightness of terminal connections.

## ***Placement of Disconnects***

Code references for this section: NEC2002 Article 230 Part VI and Article 690 Part III

Battery system disconnects should be located as close to the exit as possible, should be as close to shoulder height as possible, and should be clearly labeled. Battery system disconnects, like fire extinguishers, should be readily accessible in case of an emergency. I should not be necessary to enter deep into a room where batteries are experiencing catastrophic failure to actuate the battery system disconnects. In addition, battery system disconnects should be readily accessible for emergency response personnel.

## ***Other Considerations***

Proper spill clean-up kits should be on hand in the event of electrolyte spills. Proper personal protective equipment (PPE) should be available for dealing with leaking cells and cleanup of electrolyte.

Smoke alarms should be placed in the electrical space where batteries are contained. The smoke alarm should be loud enough or should have a remote location indicator so the alarm can be heard outside of the electrical space. Fire extinguishers rated for electrical and chemical fires should be on hand in the event of battery failure.

In addition to any NEC requirements regarding the electrical system of the entire house, all battery enclosures shall be marked with the National Fire Protection Association's (NFPA) Hazard Warning Diamond appropriate to the battery technology contained within the enclosure.



## Brief Contest Reports

Teams have the option of submitting a brief report for each of the following subjectively judged Contest Activities:

- Architecture Jury Evaluations
- Dwelling Panel Evaluations
- Web Site
- House Tours
- Comprehensive Assessment of Thermal Comfort
- Comprehensive Assessment of Indoor Air Quality
- Comprehensive Assessment of Hot Water System
- Electric Lighting Quality
- Daylighting Quality

Before the Event begins, reports will be given to the Jury or Panel of Judges associated with each of the Contest Activities listed above. The Jurors and Judges will use the reports to get a preview of what they will be evaluating at the Event. The Organizers also may use the contents of these reports in Solar Decathlon communications materials.

If a team chooses to submit one or more of the reports, each report must meet the following requirements:

- The length, including all text, figures, tables, and equations, may be no more than the front and back sides of a single sheet of paper.
- The body text and captions must be in 11 pt. (or larger) font size.
- One electronic copy (Microsoft Word document or Adobe PDF) of each report must be submitted to Mike Wassmer at [michael\\_wassmer@nrel.gov](mailto:michael_wassmer@nrel.gov) on or before August 9, 2005. To be considered “on time,” the reports must arrive at their intended destination by 5 p.m. (mountain time) on the due date.

### Summary of Revisions

November 2, 2004

- Clarified submission requirements.

## Codes and Compliance Requirements

The Solar Decathlon Rules and Regulations Committee will review the teams' drawings and submittals to ensure compliance with all applicable codes and Solar Decathlon Regulations. This document highlights some of the code and regulation requirements that are of particular importance, either because of the unique nature of this public event or because of critical safety issues. Although these requirements are being given particular emphasis in this document, the reviewers will evaluate the teams' drawings and submittals for compliance with all applicable codes and regulations.

### CC1. Building Planning and Construction

The building is intended to be representative of a single-family dwelling constructed in accordance with the provisions contained in the International Residential Code (IRC). Because portions of the building will be open to viewing by the general public, specific provisions of the International Building Code (IBC) also apply.

#### *CC1.1 Interior Finishes*

Interior finishes must comply with IBC, Sec. 803, and IBC, Table 803.5, Group R-3.

#### *CC1.2 Glazing*

The following hazardous locations are subject to human impact and require safety glazing:

- Glazing in doors
- Glazing in doors, surrounds, and walls enclosing bathtubs or showers
- Glazing in windows within a 24-in. (61.0 cm) arc of either vertical edge of a door and less than 60 in. (152.4 cm) above the floor
- Glazing within 36 in. (91 cm) of stairways and/or within 60 in. (152.4 cm) of the bottom edge of stair treads when the bottom edge of the glazing is less than 60 in. (152.4 cm) above a walking surface
- Glazing in panels located with all the following conditions present:
  - Pane of glazing is greater than 9 ft<sup>2</sup> (0.836 m<sup>2</sup>)
  - Bottom edge of glazing is less than 18 in. (45.7 cm) above the floor
  - Top edge of glazing is greater than 36 in. (91.4 cm) above the floor
  - Walking surface located within 36 in. (91.4 cm) of the glazing (IRC, Sec. 308.4)

### ***CC1.3     Roofing***

Provide details on the proposed roofing system. All roofing materials shall comply with IRC Chapter 9.

### ***CC1.4     Foam Plastic***

Foam plastics used for above-deck thermal insulation shall only be permitted if the foam plastic is isolated from the interior of the building with 0.5-in. (1.27 cm) thick gypsum board. Provide documentation to demonstrate compliance. (IRC, Sec. R314)

### ***CC1.5     Means of Egress***

Means of egress systems accessible to the public shall comply with IRC Chapter 10.

#### ***CC1.5.1.   Stairs***

Stair treads shall be 11-in. (27.9 cm) deep minimum with risers 7-in. (17.8 cm) maximum for any portion of the stairs accessible to the public. Neither treads nor risers shall deviate more than 0.375 in. (0.95 cm) over the entire run of the stairs. "Demonstration stairs" may use 10-in. (25.4 cm) minimum treads and 7.75-in. (19.7 cm) maximum risers. "Demonstrator" spiral stairs shall comply with the IRC. Ladders or stairs with steeper geometries may be provided as "demonstrators" but the design team should be aware that United States building codes typically do not permit their use. (IBC, Sec. 1009.3 and IRC, Sec. R311.5)

#### ***CC1.5.2.   Handrails***

Handrails shall be provided on both sides of stairs or ramps used by the public during the display. All handrails shall be designed in accordance with the Solar Decathlon Accessibility Requirements and Guidelines document and IBC Chapter 10. (IBC, 1009.11)

### ***CC1.6     Exterior Envelope***

Provide section detail of proposed wall assembly showing framing, sheathing, weather resistive barrier, flashing, and exterior cladding as applicable. (IRC, Sec. R703)

### ***CC1.7     Ceiling Height***

Ceiling height shall provide a minimum of 7 ft (213 cm) of headroom. (IRC, Sec. R305)

## ***CC1.8 Skylights***

IRC Section R308.6 regulates skylight glazing. Glazing is limited to certain types, and screening under the glazing may be required. Indicate which glazing products are to be used and provide sufficient details in the submitted plans to ensure compliance. (IRC, Sec. 308.6)

## ***CC1.9 Fire Protection and Prevention***

### ***CC1.9.1 Fire Protection Plan***

Provide a fire protection plan. This plan should indicate the location of fire extinguishers, how egress will be made from the unit, and who will be responsible for life-safety (the team's "Fire-Watch Captain") during the Event. Include a written operations plan for the fire-watch personnel.

### ***CC1.9.2 Required Equipment***

Each house will be required to have smoke detectors per IRC requirements and a fire extinguisher with a minimum Underwriters Laboratory (UL) rating of 2A-10BC. All battery system rooms or rooms containing a battery system enclosure must have a smoke detector that is either audible from outside the room or has a remote indicator that shall be monitored by the team. Smoke alarms shall be connected to the AC voltage side of the inverter and provided with independent (with the alarm) battery backup. All alarms shall be interconnected and all shall sound when one is activated. (IRC, Sec. R313)

## **CC2. Structural**

The structural drawings and calculations included in the construction drawings and submittals set must be stamped by a licensed professional engineer (PE). Obtaining the PE stamp is the responsibility of the teams, not the Organizers. The Organizers will submit stamped structural drawings and calculations to the National Park Service for final approval. It is strongly recommended that teams involve a licensed structural engineer throughout the design process, because he or she could require structural design changes that could affect other aspects of the house. In addition to meeting applicable IRC requirements, special attention must be given to the structural design challenges unique to the Solar Decathlon. These challenges include, but are not limited to, the following:

- Increased live loads because of public access to houses
- Necessity for tie-downs because of the lack of a permanent foundation (tie-downs must not penetrate more than 18 in. (45.7 cm) into the National Mall topsoil)

- Use of low-impact footings to protect the National Mall grass
- Unique wind loading conditions because of roof-mounted solar systems
- Increased dead loads because of unusual mechanical and electrical equipment, such as batteries and water storage.

The following minimum loads must be used in the structural design:

- Wind: 90 mph (40.2 m/s) (3-second gust), exposure category C (if tie-downs are not used, you must show that there is no overturning or uplifting with a safety factor of 2)
- Railings: 200 lb (890 N) concentrated load applied in any direction at any point at the top of the rail
- Interior Floor, Decks, Ramps: 50 psf (2.39 kPa) live load
- Roof: 20 psf (0.958 kPa) live load
- Soil: 1000 psf (4.79 kPa) load-bearing pressure on top of the soil
- Additional structural design requirements at the post-Event house location (to be determined by the engineer of record).

### ***CC2.1 Prescriptive Requirements***

Structural systems shall be designed in accordance with the appropriate prescriptive provisions of the IRC. See alternate materials provisions in CC2.6. For structural framing, a one-line structural plan view drawing is required at a minimum. Successive plan sheets shall be provided and shall include foundation footings, floor framing, wall locations, and roof framing. All structural components shall be listed including sizes, species and grade, and repetitive spacing (on-center distances). Include details on connections between joists and beams, floor systems and foundations, walls and floors, rafters and beams, etc. Specify proprietary hangers or other mechanical connections. (IRC, Sec.R301.1)

### ***CC2.2 Design Loads***

Structural plans shall indicate the design loads [e.g., 50 psf (2.39 kPa) floors, 100 psf (4.78 kPa) means of egress components, 20 psf (0.958 kPa) snow roof live load] and the location, size, and weight of special loads such as liquid storage tanks, mass or trombe walls, and battery storage racks. (IRC, Sec. R310.2 and Rules and Regulations, Regulation 10.3.3)

### ***CC2.3 Exterior Construction***

Structural plans shall include design details for any exterior appurtenances such as decks, stairs, ramps, awnings, canopies, and roof projections. (IRC, Sec. R301.1)

#### ***CC2.4 Specific Point Loads***

Provide wind-analysis calculations for point-load connections demonstrating the components' abilities to withstand 90-mph (40.2-m/s), exposure category C, wind conditions. Provide point-load connection details for all solar panel connections to demonstrate that the connections will resist uplift. (IRC, Sec. R301.1)

#### ***CC2.5 Foundation Details***

Provide a foundation plan for temporary set up on the National Mall. Plans shall include location and size of all pad footings and required tie-down anchors (e.g., type, number, and installation configuration) to prevent wind uplift or over-turning. (IRC, Sec. R401.1 and R401.2)

#### ***CC2.6 Alternate Materials***

Alternate materials are permitted as follows:

- Engineered Lumber (e.g., TJI's, LPI's, and BCI's) pursuant to specific manufacturer's design data. The product selected must carry a current International Code Council (ICC) Evaluation Services report.
- Structurally insulated panel systems (SIPS) pursuant to specific manufacturer's design data. The product selected must carry a current ICC Evaluation Services report. Also be advised that foam plastics must be thermally isolated from the interior of the dwelling (see CC1.3 for more details).
- Engineered trusses (floor or roof) must be designed in accordance with IRC Sections R502.11 or R802.10 as appropriate. Individual truss reports shall be provided for review and shall bear the seal of a registered design professional. (IRC, R104.11)

#### ***CC2.7 Structural Steel***

Provide structural details for load-carrying structural steel assemblies. Include welded or bolted connections within the assembly and where attached to other structures. (IRC, R301.1.3)

### **CC3. Electrical (non-PV)**

#### ***CC3.1 Drawing Requirements***

The following requirements are in addition to the requirements listed in the "Drawings and Submittals (Contest 3 Details)" document under the "Electrical" bullet:

- Electrical plan(s) must include layouts of proposed receptacles, switches, light fixtures, smoke alarms, ceiling fans, etc.
- Provide a key for electrical symbols used in the electrical plans. (IRC, Sec. R106.1.1)

### ***CC3.2 Outdoor Receptacles***

Any receptacles used on the exterior of the building must be ground-fault circuit-interrupter (GFCI) protected. Enclosures provided must be suitable for damp locations. (IRC, Sec. E3802.3)

### ***CC3.3 Arc-Fault Circuit Protection***

Any AC circuit providing power to bedrooms shall be protected with arc-fault circuit protection. (IRC, Sec. E3802.11)

### ***CC3.4 Ground-Fault Circuit Protection***

Any AC receptacles located in kitchens or bathrooms shall be GFCI protected. (IRC, Sec. 3802.1 and 3802.6)

## **CC4. Electrical (PV)**

All houses must meet all applicable electrical requirements stated in the 2002 National Electric Code (NEC2002). Particular attention should be paid to Articles 690, 480, 445, 250, 310, 400, and 240, which refer to photovoltaic system design, storage batteries, generators, grounding, conductors for general wiring, flexible cords and cables, and over-current protection devices, respectively. Teams are also encouraged to read the following publication: Wiles, John C. (2001). *Photovoltaic Power Systems and the National Electric Code: Suggested Practices*, Sandia Report SAND2001-0674.

### ***CC4.1 Drawing Requirements***

Provide details on the proposed PV system along with a key for symbols used in the drawings. Such details shall include information on the photovoltaic panels, distribution (e.g., wiring, inverters, switch gear, and over-current protection), and storage equipment. (IRC, Sec. R106.1.1)

### ***CC4.2 Equipment Listings***

All equipment shall carry an approved testing agency's listing. Provide manufacturer's listing information for the PV equipment selected. (IRC, Sec. E3303.3)

## **CC5. Mechanical (non-solar)**

### ***CC5.1 Drawing Requirements***

Provide a key for symbols used in the drawings. (IRC, Sec. R106.1.1)

### ***CC5.2 Return Air***

Return air shall not be taken from a bathroom, kitchen, mechanical or furnace room. Return air shall not be taken where there is a presence of flammable vapors (e.g. battery storage room). (IRC, Sec. M1602.2, Items 2 and 4)

### ***CC5.3 Outside Air***

#### ***CC5.3.1 Intake Location***

Outside air shall not be taken closer than 10 ft (304.8 cm) from an appliance or plumbing vent, or discharge outlet of an exhaust fan [unless the intake is located at least 3 ft (91.4 cm) below the vent or fan discharge]. (IRC, Sec. M1602.2, Item 1)

#### ***CC5.3.2 Screens***

Outside air inlets shall be provided with a screen with openings 0.25 in. (0.64 cm) to 0.5 in. (1.27 cm). (IRC, Sec. M1602.3)

### ***CC5.4 Bathroom Ventilation***

Bathrooms shall be provided with mechanical ventilation systems capable of providing 50 cfm (23.6 L/s) for intermittent ventilation or 20 cfm (9.4 L/s) for continuous ventilation, or provide windows allowing 1.5 ft<sup>2</sup> (0.139 m<sup>2</sup>) opening for natural ventilation. (IRC, Sec. R303.3)



## **CC6. Mechanical (Solar)**

### ***CC6.1 Drawing Requirements***

Provide plan details for any proposed solar mechanical systems. Provide details on collectors, fluid distribution, heat exchangers, etc. along with a key for symbols used in the drawings. (IRC, Sec. 106.1.1)

### ***CC6.2 Cross Connection***

Provide details for the solar hot water system. Provide details indicating if potable water or other heat transfer liquids will be employed. If other than potable water is used, an approved heat exchanger shall be employed to isolate potable water from transfer fluids. (IRC Section R106.1.1)

### ***CC6.3 Access***

Solar collectors, controls, dampers, fans, and pumps shall be accessible for inspection, maintenance, repair, and replacement. (IRC, Sec. M2301.2.1)

### ***CC6.4 Roof Mounted Collectors***

The roof shall be constructed to support all loads imposed by the collectors. If collectors are intended to serve as the roof covering, documentation shall be provided to determine compliance with the roofing provisions in IRC, Chapter 9. If the collectors will be placed over the roof covering, the collectors and supporting structure shall be constructed of non-combustible material or fire-retardant-treated wood equivalent to that required for the roof covering. (IRC, Sec. M2301.2.2)

### ***CC6.5 Pressure and Temperature Relief***

Pressure- and temperature-relief valves shall be provided for components under pressure. Relief devices shall be installed in sections of the system so that a section cannot be valved off or isolated from a relief device. (IRC, Sec. M2301.2.3)

### ***CC6.6 Vacuum Relief***

A vacuum relief valve shall protect system components that might be subjected to pressure drops below atmospheric pressure during operation or shutdown. Indicate if this system is subject to vacuum conditions. (IRC, Sec. M2301.2.4)

### ***CC6.7     Expansion Tanks***

Expansion tanks in solar systems shall be installed in accordance with IRC, Section M2003 in closed-fluid loops that contain heat transfer fluid. (IRC, Sec. M2301.2.6)

### ***CC6.8     Solar Loop Isolation***

Valves shall be installed to allow the solar collectors to be isolated from the remainder of the system. (IRC, Sec. M2301.2.8)

### ***CC6.9     Maximum Temperature Limitation***

Systems shall be equipped with means to limit the maximum water temperature of the system fluid entering or exchanging heat with any pressurized vessel inside the dwelling to 180°F (82°C). This protection is required in addition to required temperature and pressure relief valves in IRC, Section M2301.2.3. (IRC, Sec. M2301.2.9.)

### ***CC6.10   Collector and Thermal Storage Unit Labeling***

Collectors and storage units shall be listed and labeled to show the manufacturer's name, model number, serial number, collector weight, collector maximum allowable temperatures and pressures, and the type of heat transfer fluids that are compatible with the collector and storage units. (IRC, Sec. 2301.3)

### ***CC6.11   Prohibited Heat Transfer Media***

Flammable gasses and liquids shall not be used as heat transfer fluids. (IRC, Sec. M2301.4)

### ***CC6.12   Backflow Prevention***

All connections from the potable water supply to solar systems shall comply with IRC, Section P2902.4.5. (IRC, Sec.M2301.5)

## **CC7. Plumbing**

### ***CC7.1 Drawing Requirements***

The following requirements are in addition to the requirements listed in the “Drawings and Submittals (Contest 3 Details)” document under the “Mechanical and Plumbing” bullet:

- Provide a labeled isometric diagram of the proposed plumbing system for review. Clearly indicate waste lines, vent lines, potable water supply, heat exchange equipment, and the type of any heat exchange fluid other than potable water.
- Provide a key for symbols used in the drawings. (IRC, Sec. 106.1.1)

### ***CC7.2 Water Closet Demonstration***

Water closets (W.C.) are installed for demonstration only and shall not be connected to any portion of the gray water disposal system. The W.C. shall be attached to a PVC or ABS 4-in. (10.2 cm) to 3-in. (7.62 cm) water-closet flange provided with a capped end. The cap shall be located as close as possible to the flange fitting. No structural member shall be cut or otherwise damaged to accommodate the W.C. flange assembly.

### ***CC7.3 Plumbing Wall – Structural***

Recommendation: Create a dedicated plumbing wall with thickness sufficient to allow pipe penetrations within the studs not exceeding 60% of the stud width in non-bearing walls. (IRC, Sec. 602.6)

### ***CC7.4 Shower Mixing Valves***

Shower mixing valves shall be pressure balanced, thermostatic mixing, or a combination of the two, with the high limit set at 120°F (48.9°C) to prevent scalding. (IRC, Sec. P2802.3 and P2708.3)

### ***CC7.5 Backflow Prevention***

Backflow prevention is required to isolate the potable water supply from the solar systems. See IRC Section P2902.2 for permissible devices. Because this project uses supply tanks for potable water, the use of a separate and isolated fill system for the solar component may be deemed acceptable backflow prevention. (IRC, Sec. P2902.2)

## **CC8. ADA**

### ***CC8.1 Accessible Route – Interior***

An accessible route shall be provided within the unit to all spaces accessible to the public. Accessible routes shall be designed in accordance with Regulation 10.1 in the Rules and Regulations. Other accessible features may be included in rooms such as kitchens and bathrooms at the discretion of the designers. If any of the features are intended for use by the public, they shall be accessible.

### ***CC8.2 Accessibility – Upper Level Roof Deck and Interior Second Floor/Loft Levels***

This building is intended to demonstrate a single-family dwelling that is not regulated by any federal accessibility standard. However, the building is open to the public for educational purposes and must be accessible in all primary function areas. Therefore, any portion of the building where the public is permitted must be on an accessible route. The Americans with Disabilities Act (ADA) requires an elevator to be installed in buildings (funded pursuant to Title II) where an accessible route is required to stories above the first floor (such as the roof deck, second floor, or loft). The 3000-ft<sup>2</sup> exception located in IBC Section 1104.4 Exc. 1 is superseded by Federal regulation.

Following a discussion with a representative of the ADA Assistance Center, it appears acceptable to “demonstrate” a roof deck, loft, or upper level accessed via a stair, or other means of inaccessible access as long as no member of the public is allowed to access the space during the public display. It is also advisable that students not occupy the area during public viewing. Any provided means of access shall be fully gated or cordoned off to inhibit entry. Adherence to these guidelines should remove any perception that the upper level is being used as a primary function and therefore subject to the accessibility provisions of the ADA.

### ***CC8.3 Accessibility – Ramps***

The following are the most important regulations regarding ramps:

- The slope cannot exceed 1:12
- 60-in. (152.4 cm) landings are required at the top and bottom of the ramp
- Handrails are required if the ramp’s rise exceeds 6 in. (15.2 cm). [American Disabilities Act Accessibility Guidelines (ADAAG), Sec. 4.8]

#### ***CC8.4 Changes In Elevation***

All changes in elevation (including even minor changes in areas such as door thresholds) must be considered along an accessible route. Changes not exceeding 0.25 in. (0.635 cm) are acceptable. Elevation changes between 0.25 in. (0.635 cm) and 0.5 in. (1.27 cm) shall be beveled at a maximum of 1:2. Any higher change in elevation shall be by a ramp with a maximum slope of 1:12. (ADAAG, Sec. 4.5.2)

#### ***CC8.5 Doors and Door Approaches***

All doors shall comply with ADAAG Section 4.13. Doors that can be fixed in an open position may be accepted as part of the accessible route if 32-in. (81.3 cm) minimum clearance is provided through the door opening with the door secured in the fully open position. (ADAAG, Sec. 4.13)

## **Communications**

### **[Suggestions for Making Your Web Site a Winner](#)**

Advice from Web site development professionals at the National Renewable Energy Laboratory

### **[Instructions for Submitting Images](#)**

### **[Guidelines for Sponsor Recognition on the National Mall](#)**

Guidance and requirements for recognizing Event and Team Sponsors on the National Mall

# Suggestions for Making Your Team's Solar Decathlon Web Site a Winner

## Brainstorm and Think!

Who are your target audiences (users)? Although the contest requirements stipulate a consumer audience, you may want to design your Web site for more than just that audience.

- What do you want to accomplish? Yes, your Web site is part of a contest, but you may have goals in mind other than just winning the contest (e.g. attracting sponsors).
- What is your team's mission? What is its "brand?" What are your key messages? All of these ideas should be integrated into your content and be evident to the user—we're not talking about a boring bulleted list, here!
- What images and content will compel users to visit your site? Look at other Web sites for design and content ideas. Pick out samples that impress you with their content, navigation, and appealing design.
- What's the best way to organize site content? Remember, your site will change over time. Content will expand. Goals for the site may change. Think ahead and design your site so that it doesn't have to be redesigned later.

## Design for Usability

- Usability is the "total user experience" and involves all the components of a Web site: content, information architecture (content organization), and design.
- When you design and develop your Web site, you must remember that **you do not represent your users—their needs may be different than you think**. A Web site that has good usability is designed and developed with the user in mind. Here are some things to keep in mind as you design your Web site:
  - o Focus on the users' needs, tasks, and goals.
  - o Spend time on initial research and requirements—scope out the project (clearly define audiences, look at other sites for inspiration, get educated about Web site development).
  - o Emphasis should be on the iterative design process—research, scope, develop concept, test, revise, test, revise—a lot of this can be done on paper before you actually code anything.
- Take a look at these specific Web site usability resources recommended by the famous Web guru, Jakob Nielsen before you get started:
  - o <http://www.useit.com/jakob/webusability/>
  - o <http://www.useit.com/homepageusability/>
  - o <http://www.useit.com/books/>

## Repeat Daily, “Content is King”

- Fancy design, flashy Flash, groovy animation, and other Web site bells and whistles do not compensate for poor content
- Take a look at these specific Web development and Web writing sites before you get started:
  - The U.S. Department of Energy’s (DOE) Office of Energy Efficiency and Renewable Energy’s (EERE) Web writing guidelines: <http://www.eere.energy.gov/communicationstandards/web/writing.html>
  - *Sun Microsystems* Web writing guidelines: <http://www.sun.com/980713/webwriting/>
  - An online Web style guide: <http://www.webstyleguide.com/>
  - Jakob Nielsen’s Web site: <http://www.useit.com/papers/webwriting/>

## Be Original

- Write original content. It is okay to adapt material from other sources. But rewrite that material into your own words, so it is specifically focused on your Solar Decathlon project.
- Do not, under any circumstances, plagiarize. Do not cut and paste large slabs of text from another Web site or other published source. Plagiarism is usually very obvious to the user. Don’t gamble that the judges will miss it.
- Make sure you have not violated any copyrights. At the least, get written permission to use content from another Web site or other published source. Cite the source of that information on your Web site. Your school may have specific rules about using copyrighted material. You should find out what those rules are and follow them. Look at EERE’s information about copyright: <http://www.eere.energy.gov/communicationstandards/web/copyright.html>
- Create an original look. Don’t use just the generic ideas, images, colors, backgrounds, and fonts from some “Web-site-from-a-box” development software.

## Make it Work for the Web

- Read EERE’s tips for organizing, writing, and labeling your Web site content; notice how the tip pages follow the guidelines presented <http://www.eere.energy.gov/communicationstandards/web/writing.html>
- Make each page autonomous. In other words, don’t assume that the reader has read all the other pages of your Web site and will, therefore, understand a fleeting reference to a bit of information from another page. You can add hyperlinks to facilitate a user’s understanding of content.



- Optimization: Remember that your site will be indexed in search engines such as Google, Yahoo, and MSN Search. Follow EERE's online writing tips so your HTML pages will have good titles and summaries in search results. If your site includes PDFs or native file formats such as Microsoft Word, Excel, and PowerPoint, follow EERE's standards and recommended practices so these files will also have good titles and summaries in searches. Search engines are disregarding meta tags, so concentrate on writing good content instead of writing meta tags that describe your content.  
<http://www.eere.energy.gov/communicationstandards/web/writing.html>  
<http://www.eere.energy.gov/communicationstandards/web/pdfs.html>  
<http://www.eere.energy.gov/communicationstandards/web/native.html>
- Be concise and get to the point. Break up content into chunks that are both easy to find and easy to read. Web site users have less patience than readers of hard copy, because reading from a screen is more difficult, and it's just so darned tempting to "click" away.

## **Be Appropriate**

- Use audience-appropriate language. At least one of your target audiences is made up of average consumers. Make content friendly to average folks; they don't understand architect or engineer speak. Avoid highly technical language. Define terms where necessary. Avoid jargon always.
- Obviously, profane, derogatory, or otherwise insulting language is not appropriate
- Avoid critical and negative language
- Choose graphics carefully. Use the right graphic files (.jpg files for photos, .gif files for graphics, especially if the graphic contains text). Be sure to constrain the proportions of an image when it is resized. Don't rely on the HTML image size tag to determine the size of an image. The image size should be set in a photo-editing program.

## **Build in Added Attractions**

- Make it personal; maybe even use a little humor. Let the user know that your team is made up of real people. Intersperse photographs of the team doing stuff. Add entertaining captions. But use good taste and don't denigrate your project by giving it an unappealing nickname or by alluding to inside jokes.
- Add some interactivity. How about a quiz with instant feedback to the reader? Or an energy-saver calculator? But don't make interactivity too complicated—keep the number of clicks and load times to a minimum.
- Include links to other Web sites, if those other sites contain really appropriate material. Links can sometimes make your Web site fair better in search engines too. Be careful: the danger here is that the reader may find the other Web sites more interesting than yours and never come back.

## Test for Usability

- Testing your Web site on people who represent your target users is invaluable to creating an effective site.
- When to test? Early! The earlier you test, the easier it is to make changes.
- Who to test?
  - o Not your team members!
  - o Family, friends, sponsors, students and faculty, representatives from your school's media relations office. Testers should have at least average computer and Internet experience.
- What to test?
  - o Ease and efficiency of use—can the users find the information they're looking for easily? With a minimal number of clicks? Is it easy to return to a previous page or to get to other pages on the site?
- How to test? Here's one inexpensive way:
  - o Paper Prototypes
    - Hand sketches
    - Photocopies, print outs, or screenshots of early design concepts
    - Hardcopies or electronic files of content or content outline
    - Combination of any of the above.
  - o Why Paper Prototypes?
    - Uses minimal resources
    - Easy way to try out multiple ideas
    - Facilitates buy-in: if you choose testers who are also sponsors, and people who want to follow the competition—people who will actually use the site—they will feel like they're going to make a difference, and they will feel more excited about being part of the project.
    - Validation—you know the design, architecture and content work.
  - o What can be evaluated?
    - Information architecture (content organization)
    - Navigation
    - Naming, layout, groupings, and design of navigation elements
    - Content
    - Terminology and language
    - Get help from experts

- Recruit a student who is an experienced Web producer or who is studying Web design and development. Ask that person to assume ownership of the Web site.
- Contact the English or Communications Department of your school and recruit a strong writer and copy editor onto your Solar Decathlon team. Web designers, producers, and developers are not typically content providers. Find a writer to do the writing. (Remember: content is king.)
- Recruit a graphic designer onto your team—not all graphic designers can design for both Web and print; make sure you’ve got both areas covered.

## Wrap it Up

- Spell check programs are free, readily available, and easy to use. Run each Web page through a spell check.
- Spell check programs aren’t enough. Have a copy editor review the site for readability, spelling, and grammar.
- Systematically check all navigation and other links—this is an essential and painstaking process, even mind numbing, but it has to be done.
- Finally, when you finish creating your Web site, find someone who has never seen it before and whose judgment you trust. Ask him or her to read through your Web site. You’ll be surprised at the errors that person will find.

## Ongoing Maintenance

- Update content as frequently as is appropriate.
- Change the photos.
- Regularly check all links to ensure they are still functioning.
- Make sure the "Last Updated" message changes appropriately.
- Spell check, copy edit, and check all new links when you update the site.

## Additional Resources

Award-winning Web sites, Webby Awards: <http://www.webbyawards.com/>

Web Monkey: A How-to Guide for Web Developers: <http://hotwired.lycos.com/webmonkey/>

Introduction to HTML: <http://www.cwru.edu/help/introHTML/toc.html>

HTML Goodies: <http://www.htmlgoodies.com/>

New Architect Magazine; <http://www.webtechniques.com/>

User Interface Engineering: <http://www.uie.com/>

Cascading Style Sheets: <http://www.htmlhelp.com/reference/css/>

### *Online Publications*

WebReview.com: <http://webreview.com/>

E-newsletters and Internet.com: <http://e-newsletters.internet.com/>

WebDeveloper.com <http://www.webdeveloper.com/>

### *Print Publications*

Homepage Usability: 50 Websites Deconstructed, Jakob Nielsen. 2001 (113 guidelines for homepage design; available via <http://www.useit.com/> referenced earlier)

Web Design in a Nutshell, Jennifer Niederst. 2001

Learning Web Design: A Beginner's Guide to HTML, Graphics, and Beyond, Jennifer Niederst. 2001

HTML 4 for the World Wide Web, Fourth Edition: Visual QuickStart Guide (4th Edition), Elizabeth Castro. 1999

HTML & XHTML: The Definitive Guide, Chuck Musciano, Bill Kennedy. 2000

JavaScript: The Definitive Guide, David Flanagan. 2001

Cascading Style Sheets: The Definitive Guide, Eric A. Meyer. 2000

Information Architecture for the World Wide Web, Louis Rosenfeld, Peter Morville. 2002

## Instructions for Submitting Images (Graphics and Photographs)

To ensure that the Organizers can use your images most effectively, we ask that you follow these instructions. You must include the information we will need when you submit files, or we will not credit the image. All images may be made available to the general public via the U.S. Department of Energy, the National Renewable Energy Laboratory, and the Solar Decathlon sponsor Web sites with unrestricted use. Images and any publications in which the images appear will be viewable without restrictions on the Internet.

### Submittal Requirements:

- Format: Electronic files (TIFF or JPEG)
- Size: 8 in. by 10 in. (or closest metric equivalent), minimum
- Resolution: 300 dpi (or closest metric equivalent), minimum.

### Information we will need:

- Name, phone number, and email of person submitting image
- Image description
- If a photograph:
  - Date photograph was taken
  - Place photograph was taken
  - Photographer's name and affiliation
- If a graphic image:
  - Name of person or organization to credit

### How to send us your images:

- Solar Decathlon ftp site ([ftp://ftp.nrel.gov/pub/solar\\_decathlon/](ftp://ftp.nrel.gov/pub/solar_decathlon/)). Drop image files into the folder "submit\_images." You will not be able to see that your file has been successfully transferred. Please notify the specific requestor of the image files when the file has been transferred, and he or she will ensure that the transfer was successful. Include the information we will need in your notification.

- Email to a specific requestor—ask for email address. Include the information we need in your email.
- Image files on disc or CD may be mailed to a specific requestor at NREL—ask for a mailing address. Include the information we will need in a cover letter.

#### **Summary of Revisions**

November 2, 2004

- Updated procedure for dropping image files into “submit\_images” folder on ftp site.

## **Guidelines for Sponsor Recognition on the National Mall**

The National Park Service (NPS) has strict rules that will affect the way in which the Solar Decathlon teams and Organizers recognize Team and Event Sponsors. The Solar Decathlon Organizers also have developed rules that affect sponsor recognition. The Organizers reviewed the relevant NPS document regulating events on the National Mall in Washington, D.C., *National Capital Field Area (NCFA) Requirements for Special Events Held on Parkland*, as a starting point to develop the guidelines contained in this document. The Solar Decathlon Rules and Regulations Committee provided additional guidelines. The Organizers consult regularly with NPS regarding all plans for the Solar Decathlon, and the Rules and Regulations Committee meets regularly in an ongoing process of developing rules and regulations for the Project. Additional guidelines may be developed at a later date. The Organizers interpret NPS rules and regulations to the best of their abilities. They will attempt to get clear approval from NPS for plans for the Event at all times, but NPS has the final word in these matters. It is possible that despite this guidance, a team may be requested to remove items NPS does not consider appropriate for the Event.

Within certain restrictions, it is possible for teams to use their sponsors' logos in and on their Solar Decathlon houses. These restrictions apply but are not limited to all communications materials that will be on display or distributed at the Event on the National Mall. These restrictions apply to both the interior and exterior of your house. Any communications materials may be used only to identify the Solar Decathlon or a portion of the Solar Decathlon (e.g., communications materials related to one of the Contests). Sponsors may be recognized with text, logos, or both, but the text and logos must appear in conjunction with Solar Decathlon text and logo and may not be larger than one-third the size of the Solar Decathlon text and logo. The use of commercial notices or advertisements, models of commercial products, or structures representing commercial products is strictly forbidden.

### **Guidance Regarding Communications Materials**

To provide guidance, the Organizers have developed requirements for some communications materials the teams may be considering. These requirements apply to but are not limited to the materials listed in this document. All communications materials, except those prepared specifically for and viewed only by the judges for other Contests (e.g. materials prepared for the architecture jury), will support the goal of Contest 4: Communications—to educate consumers about energy efficiency and solar energy. Communications products will be targeted to an average consumer audience and will exist for the purposes of describing and explaining each team's house design, Construction, Assembly, functioning, and performance, including the solar energy and energy efficiency design strategies and technologies in the house, and each team's process and experience in the Project.

### ***Signs, Exhibits, Posters***

Signs, exhibits, and posters will exist only to support the goal of Contest 4 as described above. Signs, exhibits, and posters the Organizers determine do not support this goal, that exist largely for the recognition of sponsors, (or both) will be removed. All signs, exhibits, and posters should contain the Solar Decathlon logo or Solar Decathlon title text to clearly identify connection to the Event. If the content of signs, exhibits, and posters pertains to a specific component of the Event (e.g. one of the Contests), indicate to which component it pertains. Any text that refers to sponsors or any sponsor logos should not be greater than one-third the size of the Solar Decathlon title text, the text that identifies a specific component of the Event, or the Solar Decathlon logo. If sponsors are recognized through logos, the Solar Decathlon must be recognized using the Solar Decathlon logo. If text is used to recognize sponsors, either text or logo may be used to recognize the Solar Decathlon.

### ***Plaques, Photos, and Wall Art***

Plaques, photos, and wall art will exist only to add aesthetic value to the house or to support the goal of Contest 4 as described above. Plaques, photos, or wall art that the Organizers determine do not add aesthetic value to the house, do not support this goal, exist largely for the recognition of sponsors, (or any combination of the three) will be removed. Any plaques, photos, or wall art that recognize sponsors should contain the Solar Decathlon logo or Solar Decathlon title text to clearly identify their connection to the Event. If the content of the plaques, photos, or wall art pertains to a specific component of the Event (e.g. any of the Contests), indicate to which component it pertains. Any text that refers to sponsors or any sponsor logos should not be greater than one-third the size of the Solar Decathlon title text, the text that identifies a specific component of the Event, or the Solar Decathlon logo. If sponsors are recognized through logos, the Solar Decathlon must be recognized using the Solar Decathlon logo. If text is used to recognize sponsors, either text or logo may be used to recognize the Solar Decathlon.

### ***Furnishings***

Home furnishings (e.g., furniture, floor and window coverings, clocks, sculptures, knick knacks, figurines, bookends) in the house will exist only to add aesthetic value. Any furnishings that are used to recognize sponsors will be removed.

### ***Appliances and Electronics***

"Off-the-shelf" appliances and electronics that feature a "built-in" manufacturer's logo are acceptable. Marketing and sales material will not be adhered or attached to appliances and electronics or distributed in any other way on the National Mall.



### ***Publicity Materials and Printed Materials for Distribution on the National Mall***

The teams' brochures, binder or folder containing the Media/VIP kit, and any materials within the binder or folder (see [Regulation 3.2, Project and Event Sponsor Recognition](#)) should contain the Solar Decathlon logo or Solar Decathlon title text to clearly identify connection to the Event. If individual contents in the binder or folder pertain to specific components of the Event (e.g. one of the Contests), indicate to which component they pertain. Any text that refers to sponsors or any sponsor logos should not be greater than one-third the size of the Solar Decathlon title text, the text that identifies a specific component of the Solar Decathlon, or the Solar Decathlon logo. If sponsors are recognized through logos, the Solar Decathlon must be recognized using the Solar Decathlon logo. If text is used to recognize sponsors, either text or logo may be used to recognize the Solar Decathlon.

### ***Video/Audio/Electronic Presentations***

Video/audio/electronic presentations will exist only to support the goal of Contest 4 as described above. Video/audio/electronic presentations that the Organizers determine do not support this goal, exist largely for the recognition of sponsors, (or both) will be removed. All video/audio/electronic presentations should contain the Solar Decathlon logo or Solar Decathlon title text to clearly identify connection to the Event. If the content of video/audio/electronic presentations pertains to a specific component of the Event (e.g. any of the Contests), indicate to which component it pertains. Any text that refers to sponsors or any sponsor logos should not be greater than one-third the size of the Solar Decathlon title text, the Solar Decathlon logo, or the text that identifies a specific component of the Solar Decathlon. Audio scripts must be written and recorded such that their content supports the goal of Contest 4 and clearly identifies connection to the Solar Decathlon or a component of the Solar Decathlon (e.g. any of the Contests). No more than 20% of the total time, one minute, or whichever is less, of a video/audio/electronic presentation may be dedicated to recognition of sponsors. Television- or radio-style commercial advertising are prohibited. Video and audio loops, and screensavers that serve only to recognize sponsors are prohibited.

# **Instrumentation and Monitoring: Design Considerations for Teams**

## **Introduction**

Measurements of temperature, humidity, electric power, and illuminance determine a significant portion of the Solar Decathlon scores. This document describes what the Organizers will install in teams' houses and how teams can help facilitate this work.

The location of sensors is determined via a negotiation between each Solar Decathlon team and the Organizers. The Organizers negotiate in good faith and try to achieve an equitable outcome for all teams. There is significant flexibility regarding location and wiring details. The negotiations will start well before the Event, but some details may be worked out at the last minute. Teams are welcome to propose specific locations as their house designs progress. Teams may also ask the Organizers for recommendations. The Organizers will start making proposals for sensor locations soon after they review the teams' Drawings and Submittals.

Accommodating instrumentation is not directly part of the scoring. However, sensors must be installed or teams can't get a score in the performance-based Contest Activities. Consequently, the Organizers suggest that teams accommodate the sensors sooner rather than later.

In the following sections, the primary components of the monitoring system are described:

## **Datalogger**

The datalogger box is 14 in. (36 cm) wide, 16 in. (41 cm) high, and 8 in. (20 cm) deep. It weighs about 12 lb (5 kg). The door hinge is on the left when facing the box. The Organizers are currently planning to use wired (as opposed to wireless) sensors, so a route must be provided for running sensor wires from each sensor location to the datalogger. Wires from sensors are usually inserted through the conduit bushing in the bottom of the datalogger box. These wires are usually not installed in conduit. The datalogger box is usually mounted in a vertical orientation using screws to attach it to a wall surface at a height above the floor that provides convenient working access. The typical location for the datalogger box is in a utility room or closet, near the main AC breaker panel. The box can be mounted horizontally or upside down if the normal orientation is not available. The datalogger requires a small amount of electric power (approximately 2 watts) from the house's electric system, with the burden on each house being the same. A standard 120 VAC receptacle is usually used to supply this power. The Organizers communicate with the datalogger via a wireless modem located inside or adjacent to the datalogger box. An external antenna may be required for successful wireless modem communication. However, in the past, no external antennas were required.

## **Electric Power Meters**

Up to six (6) separate AC electric power measurements will be made in each house. The AC power meters are mounted in a standard electric panel box. The box is 15 in. (38 cm) wide, 20 in. (51 cm) high, and 4 in. (10 cm) deep. The door hinge is on the left. This box is

usually surface-mounted adjacent to the main AC electric panel in the house. Wires for voltage taps and current transformers will be installed between the meter box and the circuits inside the main AC panel. Each watt-hour meter unavoidably uses a small amount of power (1–2 watts each) from the house, with the burden on each house being the same. For the installation of these meters, it is helpful to have extra room for the current transformers and extra breakers for the voltage taps.

If significant end-uses are supplied with DC rather than AC power, the Organizers plan to install shunts and voltage dividers inside the teams' DC power panels to measure the DC power. Measurement of DC power is more idiosyncratic than measurement of AC power.

With the exception of lighting, electric power consumption of separate end-uses is not directly scored in the Contests, but the Organizers are still very interested in separately measuring the electric power used in performing the tasks for each Contest Activity. The segregation of end-uses provides a more interesting comparison among the houses and may give teams more information to optimize the performance of their houses during the Competition. Therefore, it is important for teams to arrange the electrical circuits according to the Contest Activity end-uses. For example, if the dishwasher is on a separate circuit than the refrigerator, the measurement of electric power of each individual circuit will provide a more interesting interpretation of performance than if both appliances were on the same circuit. The Organizers expect the end-use measurements to include refrigerator, clothes washer, clothes dryer, dishwasher, hot water, lighting, and electric car.

Part of the scoring of Contest 8: Lighting depends on the measurement of electric power, so it is important that the lighting circuits are not contaminated by any other end-uses. The “Standard Usage Patterns” Contest Activity requires that all interior lighting used in the “Electric Lighting Quantity” Contest Activity be connected to dedicated circuits. “Dedicated” means that no other electric end-uses are connected to the dedicated lighting circuits and no interior lights are connected to circuits other than the dedicated lighting circuits. The Organizers will install current transformers on each of the dedicated AC lighting circuits to measure the lighting power as a separate end-use. If DC power is used for lighting, the Organizers will install shunts and voltage dividers for each dedicated circuit. Teams should clearly identify the dedicated lighting circuits and any receptacles connected to those circuits. The Organizers will verify that these circuits are “dedicated.”

## **Main Battery Shunt**

The scoring for Contest 9: Energy Balance requires measurement of the DC electric energy flow into and out of the battery bank. The Organizers plan to use a shunt to measure current and a voltage divider to measure the battery voltage. The installation of the main battery shunt can be time consuming because the battery cables are large and inflexible and there is typically limited space available to make the connections. Many commercially fabricated DC load centers are available with a shunt already installed. If a team's DC panel already has a shunt, the Organizers will want to share the output signal from the shunt. If the team's panel does not have a shunt, the Organizers will send one so it can be installed as the system is being built.

The Organizers need a route to run wires from the shunt and voltage divider to the datalogger. The DC load center is frequently located in the same utility space as the datalogger, so surface mounting of sensor wires is usually straightforward and appropriate.

This description of the Energy Balance monitoring approach applies to the case in which a team has only one battery bank. If a team's design includes more than one battery bank, the Organizers will duplicate the measurements for each battery bank. However, to avoid placing an excessive burden on the Organizers installing instrumentation, systems should have just one main battery bank. If a team is proposing to use more than one battery bank, it must provide justification and that justification must be approved by the Organizers.

## **Light Sensors**

Contest 8: Lighting requires that a minimum average lighting level be maintained on the work surface of the home office desk during certain hours. The Organizers will install a photometer on the desk to continuously measure the illuminance on the horizontal work surface. The photometer with its base is about 3 in. (8 cm) in diameter and about 1 in. (3 cm) high and requires a wire to connect it to the datalogger. The Organizers will negotiate with each team to determine a specific location that is representative of the task lighting and accommodates other normal activities on the desk.

## **Temperature and Relative Humidity Sensors**

A significant part of the scoring in Contest 5: Comfort Zone is derived from the measured dry bulb temperature and relative humidity inside the house. The Organizers plan to use a temperature and relative humidity sensor mounted inside a radiation shield to make this measurement. The sensor will be placed in a location that is representative of the temperature and humidity conditions through the entire house. This location will usually be between 4 and 5 ft (1 and 2 m) above the floor in the largest open room of the house. A location adjacent to a standard house thermostat is typical. In a closed bedroom, on an exterior wall, near the floor or ceiling, or near a window are all highly unlikely locations. If there is clearly more than one zone in the house, the Organizers will install more than one sensor. The objective of Contest 5 is to heat and cool the house (not to heat and cool the temperature sensor) and to maintain comfort conditions throughout the entire space.

The temperatures inside the refrigerator and freezer will be measured with thermocouples. These measurements typically require the placement of a small wire through the refrigerator or freezer door so that the gasket closes around the wire. This approach was used in the past with satisfactory results. The Organizers will identify a route for the thermocouple wires to be run from the datalogger to the refrigerator and freezer. If a team is concerned that jamming wires in the door will significantly impair the thermal performance, note that all teams are subject to the same installation approach. If a team is going to use a non-standard door gasket, the Organizers need to be made aware of it.

## Pre-Event Schedule

This document identifies the schedule of deliverables and activities that will occur before the Event begins.

<b>Deliverable/Schedule Item</b>	<b>Date</b>
Project Summary #1 due *	April 15, 2004
Preliminary team Web site due *	
Solar Decathlon Web site live and linked to team Web sites	June 1, 2004
Project Summary #2 due *	June 15, 2004
Schematic Energy Analysis Report due *	
Design Development Drawings and Submittals due *	
Solar Decathlon Pre-Event Workshop (Orlando, Florida)	January 3, 2005
Begin inspections at teams' Construction sites	January 2005
Project Summary #3 due *	February 8, 2005
Construction Drawings and Submittals due *	
Arrival and Departure Plan due *	
Computer Network Information Requirements due *	
Organizers interview teams for Event Program	March 2005 – June 2005

Team Registration *	Summer 2005
Final Project Summary due *	
As-Built Drawings and Submittals due *	August 9, 2005
Brief Contest Reports due *	
Meal Plans due *	

\* See [Pre-Event Deliverables](#) for more information.

#### Summary of Revisions

November 2, 2004

- Added meal plans to list of items due on August 9, 2003.

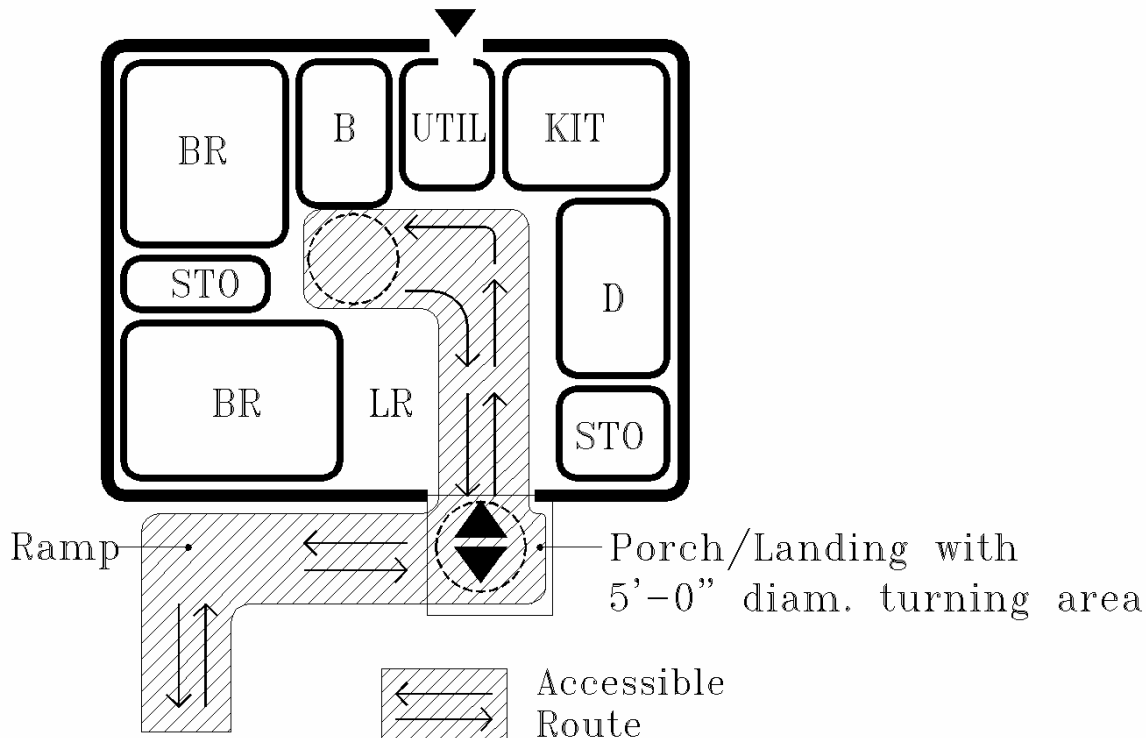
# Solar Decathlon Accessibility Requirements and Guidelines

## Acknowledgement

The Accessibility requirements reported in this document are excerpts from the **ADA Accessibility Guidelines for Buildings and Facilities (ADAAG)** as amended through January 1998. Certain sections or portions of sections that are not directly relevant to the scope of this competition have been omitted. A full copy of the guidelines is available at <http://www.access-board.gov/adaag/html/adaag.htm>

## Introduction

For the purposes of this Solar Decathlon competition, teams are required to provide, as a minimum, an “Accessible Route” available during public tours, from their lot line into and within their units (see Figure A).



**Figure A**

This diagram is intended only to provide graphic depiction of a possible accessible route into and within a unit. It is not intended to represent any direction or recommendation for the plan layout of a unit.

Areas within the units that are not intended to be accessible, should be “roped” off, or provided with some sort of barrier to protect access during public tour times. If an area is isolated from public access, it need not comply with the requirements of these Guidelines.

The “**Basic Requirements**” portion of these Guidelines describes the criteria for providing the “Accessible Route” discussed earlier.

The “**Appendix**” portion of these Guidelines is included to provide compliance criteria in verbal and graphic form for Design Teams who desire to provide public access to other spaces within the units in addition to the required “Accessible Route,” such as bathrooms, kitchens, utility areas, etc.

Compliance with Accessibility Guidelines for facilities outside the unit lot lines is not the responsibility of the contestants. Facilities include, but are not limited to the following:

- Parking
- Toilet Facilities
- Water Fountains
- Display
- Telephone
- ATMs
- Etc

## Basic Requirements

Providing an “Accessible Route” into and within the unit will consist of implementing the following criteria into the design.

1. The anticipated maximum height above grade for the unit from grade elevation is 24 inches. This will minimize ramp and stair construction.
2. The “Accessible Route” must allow the passing of wheelchairs in each direction (Figure 2), or a one way-loop must be provided which would allow a narrower route (Figure 1). Accessible route must comply with Section 4.3 of the Guidelines.

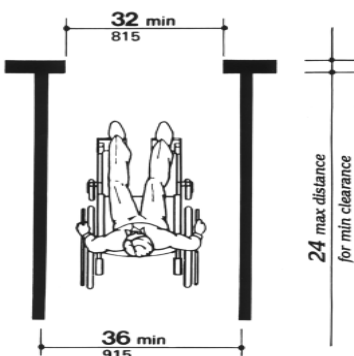


Figure 1

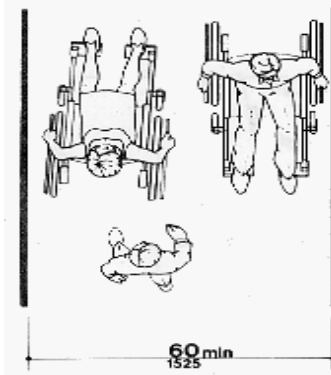


Figure 2



- Objects protruding into the Accessible Route must comply with Section 4.4 of the Guidelines (Figures 8a, 8b, 8c and 8d).

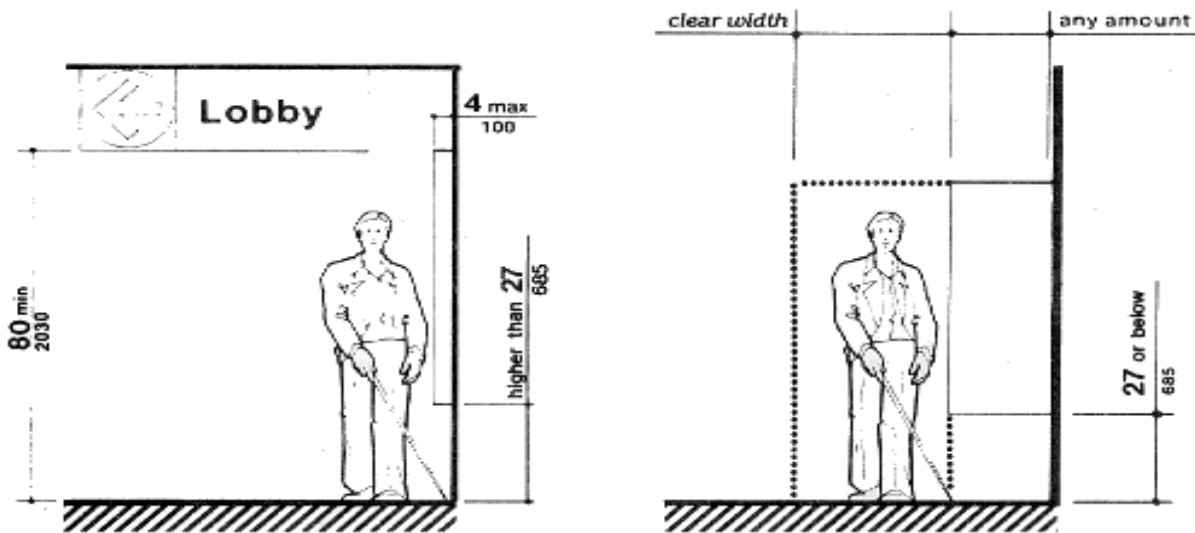


Figure 8a

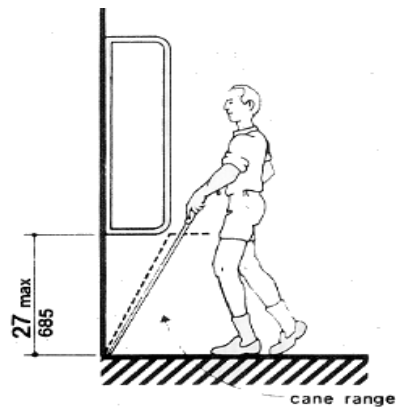


Figure 8b

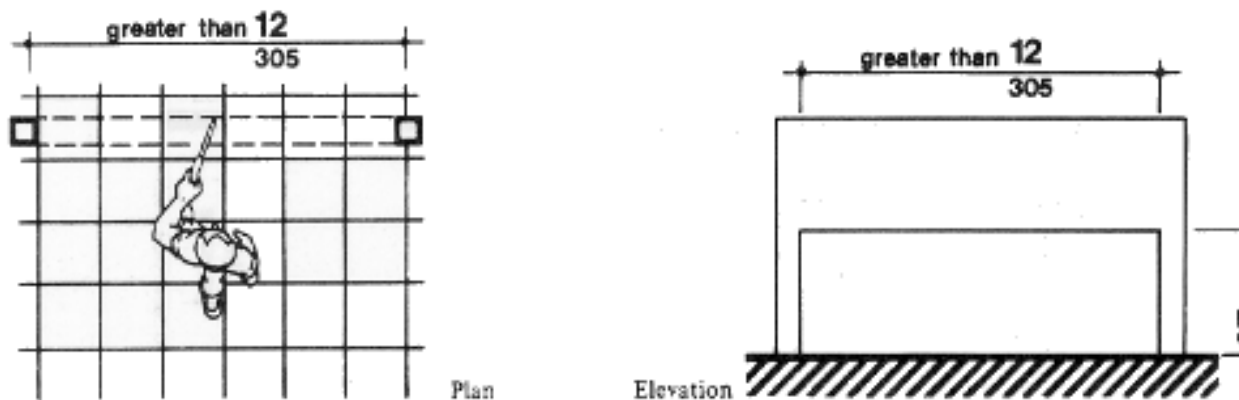


Figure 8c

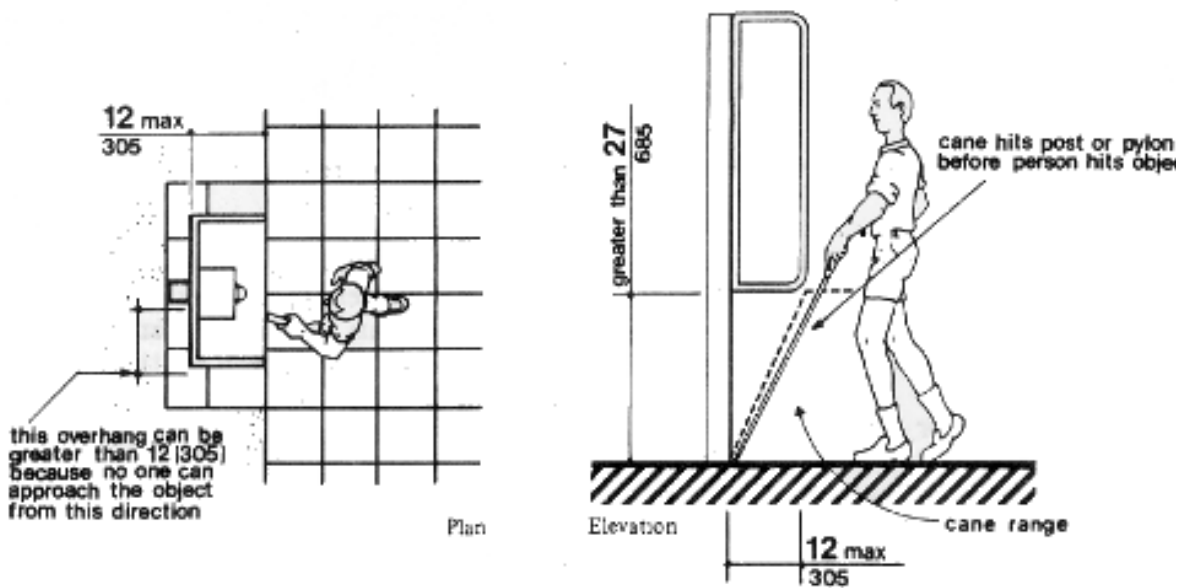


Figure 8d

4. Ground and Floor Surface along the Accessible Route must comply with Section 4.5 of the Guidelines (Figures 7c and 7d).

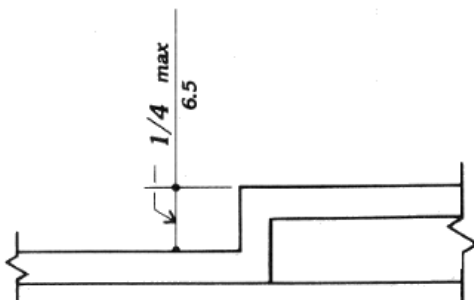


Figure 7c

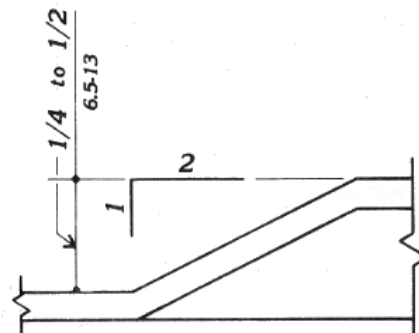


Figure 7d

5. Ramps, as defined as any part of an Accessible Route with a slope greater than 1:20, shall comply with Section 4.8 of the Guidelines, in all respects including:

- Slope and Rise
- Clear width
- Landings
- Handrails
- Cross Slope and Surfaces
- Edge Protection
- Outdoor Conditions

6. Stairs when required to be accessible by Section 4.1, shall comply with Section 4.9 of the Guidelines in all respects including:

- Treads and risers
- Nosings
- Handrails

(Figures 18, 19c, and 19d).

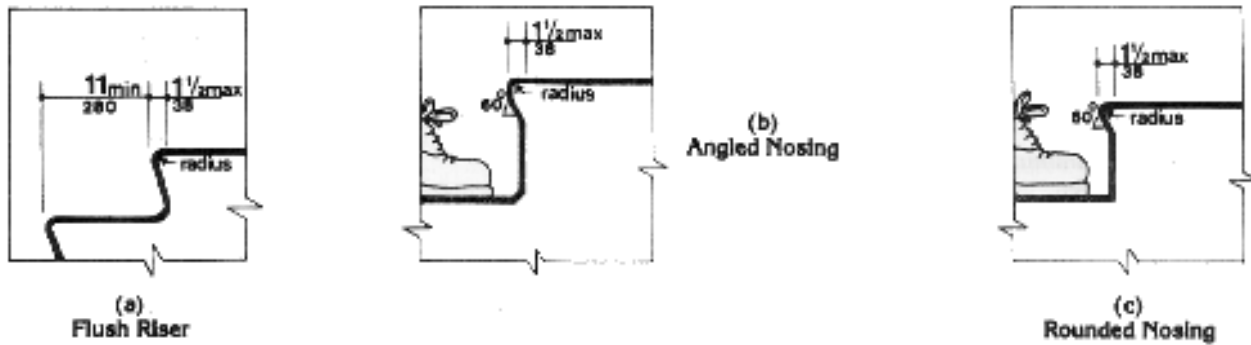


Figure 18

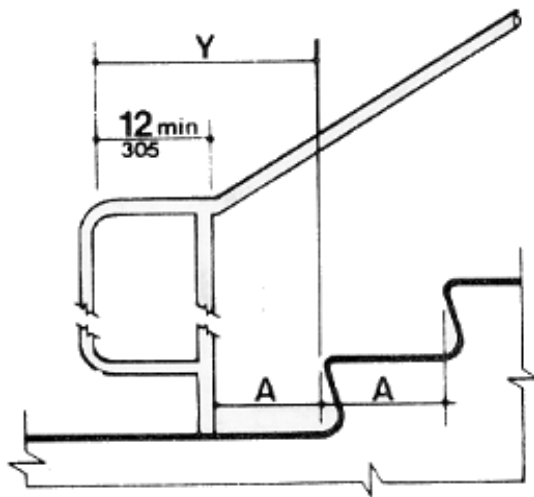


Figure 19c

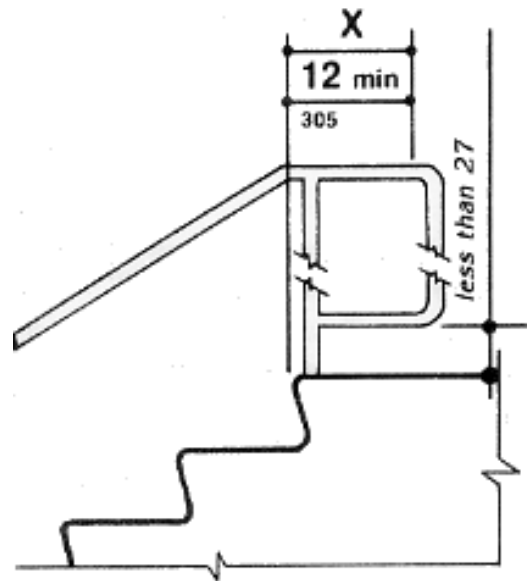


Figure 19d

7. Doors along the Accessible Route shall comply with Section 4.13 of the Guidelines in all respects including:

- Clear Width
- Maneuvering Clearances
- Thresholds
- Hardware
- Opening Force

(Figures 24, 25, and 26).

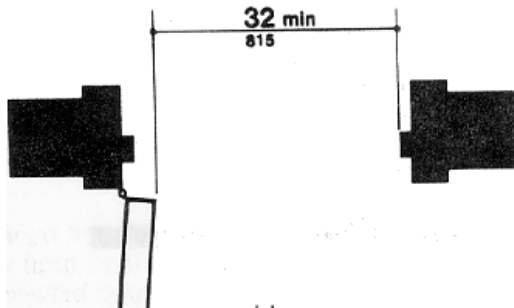


Figure 24a

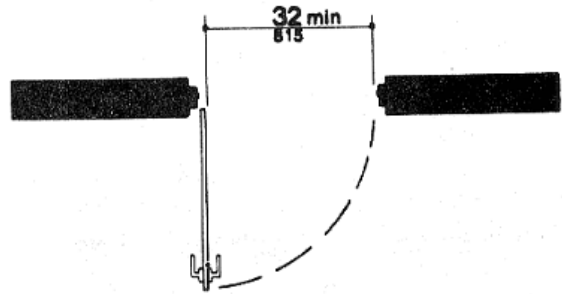


Figure 24b

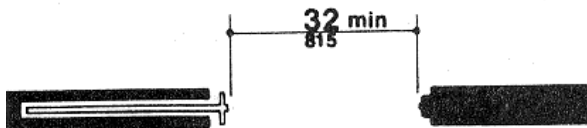


Figure 24c

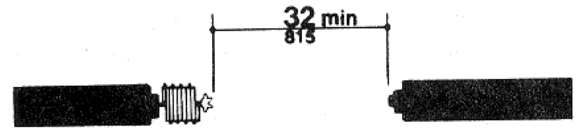


Figure 24d

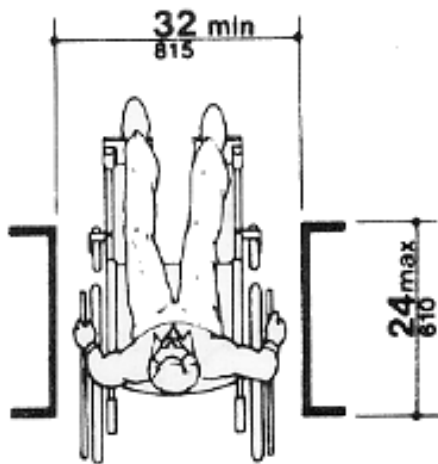


Figure 24e

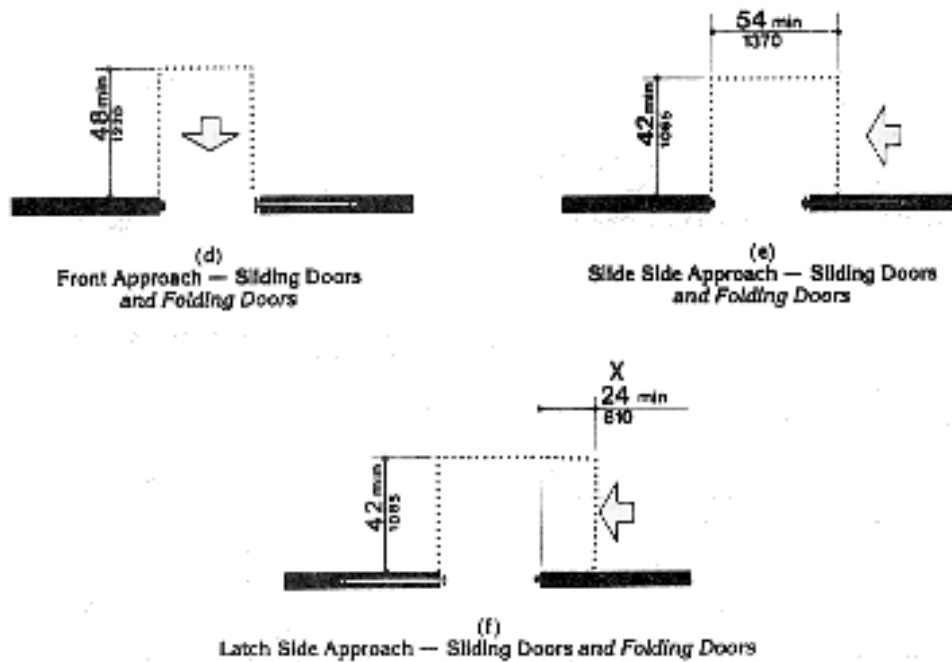


Figure 25

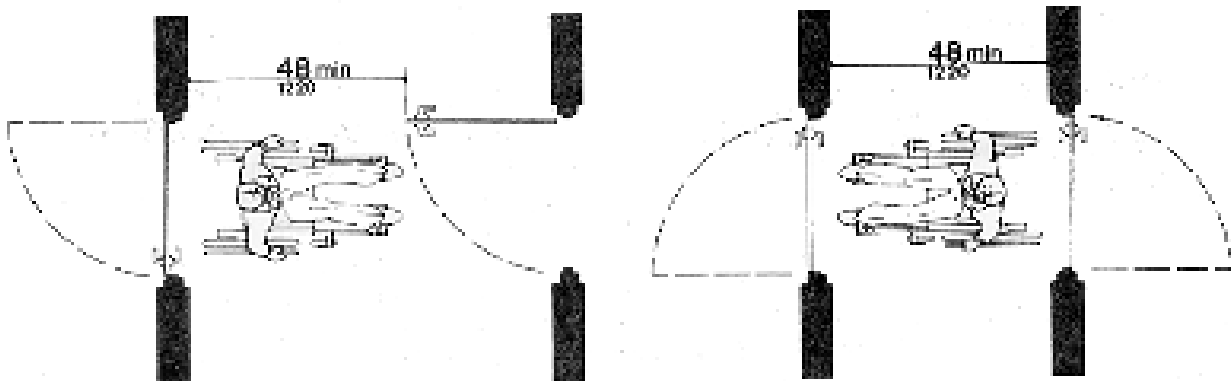


Figure 26

8. Signage along the Accessible Route, if an interactive part of the tour/display, shall comply with Section 4.30 of the Guidelines.

## Appendix

### 4.1.2 Accessible Sites and Exterior Facilities: New Construction.

An accessible site shall meet the following minimum requirements:

- (1) At least one accessible route complying with 4.3 shall be provided within the boundary of the site from public transportation stops, accessible parking spaces, passenger loading zones if provided, and public streets or sidewalks, to an accessible building entrance.
- (2) At least one accessible route complying with 4.3 shall connect accessible buildings, accessible facilities, accessible elements, and accessible spaces that are on the same site.
- (3) All objects that protrude from surfaces or posts into circulation paths shall comply with 4.4.
- (4) Ground surfaces along accessible routes and in accessible spaces shall comply with 4.5.

### 4.1.3 Accessible Buildings: New Construction.

Accessible buildings and facilities shall meet the following minimum requirements:

- (1) At least one accessible route complying with 4.3 shall connect accessible building or facility entrances with all accessible spaces and elements within the building or facility.
- (2) All objects that overhang or protrude into circulation paths shall comply with 4.4.
- (3) Ground and floor surfaces along accessible routes and in accessible rooms and spaces shall comply with 4.5.
- (4) Interior and exterior stairs connecting levels that are not connected by an elevator, ramp, or other accessible means of vertical access shall comply with 4.9.
- (7) Doors:
  - (a) At each accessible entrance to a building or facility, at least one door shall comply with 4.13.
  - (b) Within a building or facility, at least one door at each accessible space shall comply with 4.13.
  - (c) Each door that is an element of an accessible route shall comply with 4.13.
  - (d) Each door required by 4.3.10, Egress, shall comply with 4.13.
- (9)\* In buildings or facilities, or portions of buildings or facilities, required to be accessible, accessible means of egress shall be provided in the same number as required for exits by local building/life safety regulations.
- (13) Controls and operating mechanisms in accessible spaces, along accessible routes, or as parts of accessible elements (for example, light switches and dispenser controls) shall comply with 4.27.
- (14) If emergency warning systems are provided, then they shall include both audible alarms and visual alarms complying with 4.28.
- (15) Detectable warnings shall be provided at locations as specified in 4.29.

## 4.2 Space Allowance and Reach Ranges.

**4.2.1\* Wheelchair Passage Width.** The minimum clear width for single wheelchair passage shall be 32 in. (815 mm) at a point and 36 in. (915 mm) continuously (see Fig. 1 and 24(e)).

**4.2.2 Width for Wheelchair Passing.** The minimum width for two wheelchairs to pass is 60 in. (1525 mm) (see Fig. 2).

**4.2.3\* Wheelchair Turning Space.** The space required for a wheelchair to make a 180-degree turn is a clear space of 60 in. (1525 mm) diameter (see Fig. 3(a)) or a T-shaped space (see Fig. 3(b)).

**4.2.4\* Clear Floor or Ground Space for Wheelchairs.**

**4.2.4.1 Size and Approach.** The minimum clear floor or ground space required to accommodate a single, stationary wheelchair and occupant is 30 in. by 48 in. (760 mm by 1220 mm) (see Fig. 4(a)). The minimum clear floor or ground space for wheelchairs may be positioned for forward or parallel approach to an object (see Fig. 4(b) and (c)). Clear floor or ground space for wheelchairs may be part of the knee space required under some objects.

4.2.4.2 Relationship of Maneuvering Clearance to Wheelchair Spaces. One full unobstructed side of the clear floor or ground space for a wheelchair shall adjoin or overlap an accessible route or adjoin another wheelchair clear floor space. If a clear floor space is located in an alcove or otherwise confined on all or part of three sides, additional maneuvering clearances shall be provided as shown in Fig. 4(d) and (e).

4.2.4.3 Surfaces for Wheelchair Spaces. Clear floor or ground spaces for wheelchairs shall comply with 4.5.

4.2.5\* **Forward Reach.** If the clear floor space only allows forward approach to an object, the maximum high forward reach allowed shall be 48 in. (1220 mm) (see Fig. 5(a)). The minimum low forward reach is 15 in. (380 mm). If the high forward reach is over an obstruction, reach and clearances shall be as shown in Fig. 5(b).

4.2.6\* **Side Reach.** If the clear floor space allows parallel approach by a person in a wheelchair, the maximum high side reach allowed shall be 54 in. (1370 mm) and the low side reach shall be no less than 9 in. (230 mm) above the floor (Fig. 6(a) and (b)). If the side reach is over an obstruction, the reach and clearances shall be as shown in Fig 6(c).

### 4.3 Accessible Route.

4.3.1\* **General.** All walks, halls, corridors, aisles, skywalks, tunnels, and other spaces that are part of an accessible route shall comply with 4.3.

#### 4.3.2 Location.

(1) At least one accessible route within the boundary of the site shall be provided from public transportation stops, accessible parking, and accessible passenger loading zones, and public streets or sidewalks to the accessible building entrance they serve. The accessible route shall, to the maximum extent feasible, coincide with the route for the general public.

(2) At least one accessible route shall connect accessible buildings, facilities, elements, and spaces that are on the same site.

(3) At least one accessible route shall connect accessible building or facility entrances with all accessible spaces and elements and with all accessible dwelling units within the building or facility.

(4) An accessible route shall connect at least one accessible entrance of each accessible dwelling unit with those exterior and interior spaces and facilities that serve the accessible dwelling unit.

4.3.3 **Width.** The minimum clear width of an accessible route shall be 36 in. (915 mm) except at doors (see 4.13.5 and 4.13.6). If a person in a wheelchair must make a turn around an obstruction, the minimum clear width of the accessible route shall be as shown in Fig. 7(a) and (b).

4.3.4 **Passing Space.** If an accessible route has less than 60 in. (1525 mm) clear width, then passing spaces at least 60 in. by 60 in. (1525 mm by 1525 mm) shall be located at reasonable intervals not to exceed 200 ft (61 m). A T-intersection of two corridors or walks is an acceptable passing place.

4.3.5 **Headroom.** Accessible routes shall comply with 4.4.2.

4.3.6 **Surface Textures.** The surface of an accessible route shall comply with 4.5.

4.3.7 **Slope.** An accessible route with a running slope greater than 1:20 is a ramp and shall comply with 4.8. Nowhere shall the cross slope of an accessible route exceed 1:50.

4.3.8 **Changes in Levels.** Changes in levels along an accessible route shall comply with 4.5.2. If an accessible route has changes in level greater than 1/2 in. (13 mm), then a curb ramp, ramp, elevator, or platform lift (as permitted in 4.1.3 and 4.1.6) shall be provided that complies with 4.7, 4.8, 4.10, or 4.11, respectively. An accessible route does not include stairs, steps, or escalators. See definition of "egress, means of" in 3.5.

4.3.9 **Doors.** Doors along an accessible route shall comply with 4.13.

4.3.10\* **Egress.** Accessible routes serving any accessible space or element shall also serve as a means of egress for emergencies or connect to an accessible area of rescue assistance.

#### 4.4 Protruding Objects.

4.4.1\* **General.** Objects projecting from walls (for example, telephones) with their leading edges between 27 in. and 80 in. (685 mm and 2030 mm) above the finished floor shall protrude no more than 4 in. (100 mm) into walks, halls, corridors, passageways, or aisles (see Fig. 8(a)). Objects mounted with their leading edges at or below 27 in. (685 mm) above the finished floor may protrude any amount (see Fig. 8(a) and (b)). Freestanding objects mounted on posts or pylons may overhang 12 in. (305 mm) maximum from 27 in. to 80 in. (685 mm to 2030 mm) above the ground or finished floor (see Fig. 8(c) and (d)). Protruding objects shall not reduce the clear width of an accessible route or maneuvering space (see Fig. 8(e)).

4.4.2 **Headroom.** Walks, halls, corridors, passageways, aisles, or other circulation spaces shall have 80 in. (2030 mm), minimum, clear headroom (see Fig. 8(a)). If vertical clearance of an area adjoining an accessible route is reduced to less than 80 in. (nominal dimension), a barrier to warn blind or visually-impaired persons shall be provided (see Fig. 8(c-1)).

#### 4.5 Ground and Floor Surfaces.

4.5.1\* **General.** Ground and floor surfaces along accessible routes and in accessible rooms and spaces including floors, walks, ramps, stairs, and curb ramps, shall be stable, firm, slip-resistant, and shall comply with 4.5.

4.5.2 **Changes in Level.** Changes in level up to 1/4 in. (6 mm) may be vertical and without edge treatment (see Fig. 7(c)). Changes in level between 1/4 in. and 1/2 in. (6 mm and 13 mm) shall be beveled with a slope no greater than 1:2 (see Fig. 7(d)). Changes in level greater than 1/2 in. (13 mm) shall be accomplished by means of a ramp that complies with 4.7 or 4.8.

4.5.3\* **Carpet.** If carpet or carpet tile is used on a ground or floor surface, then it shall be securely attached; have a firm cushion, pad, or backing, or no cushion or pad; and have a level loop, textured loop, level cut pile, or level cut/uncut pile texture. The maximum pile thickness shall be 1/2 in. (13 mm) (see Fig. 8(f)). Exposed edges of carpet shall be fastened to floor surfaces and have trim along the entire length of the exposed edge. Carpet edge trim shall comply with 4.5.2.

4.5.4 **Gratings.** If gratings are located in walking surfaces, then they shall have spaces no greater than 1/2 in. (13 mm) wide in one direction (see Fig. 8(g)). If gratings have elongated openings, then they shall be placed so that the long dimension is perpendicular to the dominant direction of travel (see Fig. 8(h)).

#### 4.8 Ramps.

4.8.1\* **General.** Any part of an accessible route with a slope greater than 1:20 shall be considered a ramp and shall comply with 4.8.

4.8.2\* **Slope and Rise.** The least possible slope shall be used for any ramp. The maximum slope of a ramp in new construction shall be 1:12. The maximum rise for any run shall be 30 in. (760 mm) (see Fig. 16). Curb ramps and ramps to be constructed on existing sites or in existing buildings or facilities may have slopes and rises as allowed in 4.1.6(3)(a) if space limitations prohibit the use of a 1:12 slope or less.

4.8.3 **Clear Width.** The minimum clear width of a ramp shall be 36 in. (915 mm).

4.8.4\* **Landings.** Ramps shall have level landings at bottom and top of each ramp and each ramp run. Landings shall have the following features:

- (1) The landing shall be at least as wide as the ramp run leading to it.
- (2) The landing length shall be a minimum of 60 in. (1525 mm) clear.
- (3) If ramps change direction at landings, the minimum landing size shall be 60 in. by 60 in. (1525 mm by 1525 mm).



(4) If a doorway is located at a landing, then the area in front of the doorway shall comply with 4.13.6.

**4.8.5\* Handrails.** If a ramp run has a rise greater than 6 in. (150 mm) or a horizontal projection greater than 72 in. (1830 mm), then it shall have handrails on both sides. Handrails are not required on curb ramps or adjacent to seating in assembly areas. Handrails shall comply with 4.26 and shall have the following features:

- (1) Handrails shall be provided along both sides of ramp segments. The inside handrail on switchback or dogleg ramps shall always be continuous.
- (2) If handrails are not continuous, they shall extend at least 12 in. (305 mm) beyond the top and bottom of the ramp segment and shall be parallel with the floor or ground surface (See Fig. 17).
- (3) The clear space between the handrail and the wall shall be 1 - 1/2 in. (38 mm).
- (4) Gripping surfaces shall be continuous.
- (5) Top of handrail gripping surfaces shall be mounted between 34 in. and 38 in. (865 mm and 965 mm) above ramp surfaces.
- (6) Ends of handrails shall be either rounded or returned smoothly to floor, wall, or post.
- (7) Handrails shall not rotate within their fittings.

**4.8.6 Cross Slope and Surfaces.** The cross slope of ramp surfaces shall be no greater than 1:50. Ramp surfaces shall comply with 4.5.

**4.8.7 Edge Protection.** Ramps and landings with drop-offs shall have curbs, walls, railings, or projecting surfaces that prevent people from slipping off the ramp. Curbs shall be a minimum of 2 in. (50 mm) high (see Fig. 17).

**4.8.8 Outdoor Conditions.** Outdoor ramps and their approaches shall be designed so that water will not accumulate on walking surfaces.

## **4.9 Stairs.**

**4.9.1\* Minimum Number.** Stairs required to be accessible by 4.1 shall comply with 4.9.

**4.9.2 Treads and Risers.** On any given flight of stairs, all steps shall have uniform riser heights and uniform tread widths. Stair treads shall be no less than 11 in. (280 mm) wide, measured from riser to riser (see Fig. 18(a)). Open risers are not permitted.

**4.9.3 Nosings.** The undersides of nosings shall not be abrupt. The radius of curvature at the leading edge of the tread shall be no greater than 1/2 in. (13 mm). Risers shall be sloped or the underside of the nosing shall have an angle not less than 60 degrees from the horizontal. Nosings shall project no more than 1-1/2 in. (38 mm) (see Fig. 18).

**4.9.4 Handrails.** Stairways shall have handrails at both sides of all stairs. Handrails shall comply with 4.26 and shall have the following features:

- (1) Handrails shall be continuous along both sides of stairs. The inside handrail on switchback or dogleg stairs shall always be continuous.
- (2) If handrails are not continuous, they shall extend at least 12 in. (305 mm) beyond the top riser and at least 12 in. (305 mm) plus the width of one tread beyond the bottom riser. At the top, the extension shall be parallel with the floor or ground surface. At the bottom, the handrail shall continue to slope for a distance of the width of one tread from the bottom riser; the remainder of the extension shall be horizontal (see Fig. 19(c) and (d)). Handrail extensions shall comply with 4.4.

- (3) The clear space between handrails and wall shall be 1-1/2 in. (38 mm).
- (4) Gripping surfaces shall be uninterrupted by newel posts, other construction elements, or obstructions.
- (5) Top of handrail gripping surface shall be mounted between 34 in. and 38 in. (865 mm and 965 mm) above stair nosings.
- (6) Ends of handrails shall be either rounded or returned smoothly to floor, wall or post.
- (7) Handrails shall not rotate within their fittings.

**4.9.6 Outdoor Conditions.** Outdoor stairs and their approaches shall be designed so that water will not accumulate on walking surfaces.

## **4.12 Windows. (not used)**

## **4.13 Doors.**

**4.13.1 General.** Doors required to be accessible by 4.1 shall comply with the requirements of 4.13.

**4.13.2 Revolving Doors and Turnstiles.** Revolving doors or turnstiles shall not be the only means of passage at an accessible entrance or along an accessible route. An accessible gate or door shall be provided adjacent to the turnstile or revolving door and shall be so designed as to facilitate the same use pattern.

**4.13.3 Gates.** Gates, including ticket gates, shall meet all applicable specifications of 4.13.

**4.13.4 Double-Leaf Doorways.** If doorways have two independently operated door leaves, then at least one leaf shall meet the specifications in 4.13.5 and 4.13.6. That leaf shall be an active leaf.

**4.13.5 Clear Width.** Doorways shall have a minimum clear opening of 32 in. (815 mm) with the door open 90 degrees, measured between the face of the door and the opposite stop (see Fig. 24(a), (b), (c), and (d)). Openings more than 24 in. (610 mm) in depth shall comply with 4.2.1 and 4.3.3 (see Fig. 24(e)).

EXCEPTION: Doors not requiring full user passage, such as shallow closets, may have the clear opening reduced to 20 in. (510 mm) minimum.

**4.13.6 Maneuvering Clearances at Doors.** Minimum maneuvering clearances at doors that are not automatic or power-assisted shall be as shown in Fig. 25. The floor or ground area within the required clearances shall be level and clear.

EXCEPTION: Entry doors to acute care hospital bedrooms for in-patients shall be exempted from the requirement for space at the latch side of the door (see dimension "x" in Fig. 25) if the door is at least 44 in. (1120 mm) wide.

**4.13.7 Two Doors in Series.** The minimum space between two hinged or pivoted doors in series shall be 48 in. (1220 mm) plus the width of any door swinging into the space. Doors in series shall swing either in the same direction or away from the space between the doors (see Fig. 26).

**4.13.8\* Thresholds at Doorways.** Thresholds at doorways shall not exceed 3/4 in. (19 mm) in height for exterior sliding doors or 1/2 in. (13 mm) for other types of doors. Raised thresholds and floor level changes at accessible doorways shall be beveled with a slope no greater than 1:2 (see 4.5.2).

**4.13.9\* Door Hardware.** Handles, pulls, latches, locks, and other operating devices on accessible doors shall have a shape that is easy to grasp with one hand and does not require tight grasping, tight pinching, or twisting of the wrist to operate. Lever-operated mechanisms, push-type mechanisms, and U-shaped handles are acceptable designs. When sliding doors are fully open, operating hardware shall be exposed

and usable from both sides. Hardware required for accessible door passage shall be mounted no higher than 48 in. (1220 mm) above finished floor.

4.13.10\* **Door Closers.** If a door has a closer, then the sweep period of the closer shall be adjusted so that from an open position of 70 degrees, the door will take at least 3 seconds to move to a point 3 in. (75 mm) from the latch, measured to the leading edge of the door.

4.13.11\* **Door Opening Force.** The maximum force for pushing or pulling open a door shall be as follows:

(1) Fire doors shall have the minimum opening force allowable by the appropriate administrative authority.

(2) Other doors.

(a) exterior hinged doors: (Reserved)

(b) interior hinged doors: 5 lbf (22.2N)

(c) sliding or folding doors: 5 lbf (22.2N).

These forces do not apply to the force required to retract latch bolts or disengage other devices that may hold the door in a closed position.

4.13.12\* **Automatic Doors and Power-Assisted Doors.** If an automatic door is used, then it shall comply with **ANSI/BHMA A156.10-1985**. Slowly opening, low-powered, automatic doors shall comply with **ANSI A156.19-1984**. Such doors shall not open to back check faster than 3 seconds and shall require no more than 15 lbf (66.6N) to stop door movement. If a power-assisted door is used, its door-opening force shall comply with 4.13.11 and its closing shall conform to the requirements in **ANSI A156.19-1984**

## 4.16 Water Closets.

4.16.1 General. Accessible water closets shall comply with 4.16.2 through 4.16.6.

EXCEPTION: Water closets used primarily by children ages 12 and younger shall be permitted to comply with 4.16.7.

4.16.2 **Clear Floor Space.** Clear floor space for water closets not in stalls shall comply with Fig. 28. Clear floor space may be arranged to allow either a left-handed or right-handed approach.

4.16.3\* **Height.** The height of water closets shall be 17 in. to 19 in. (430 mm to 485 mm), measured to the top of the toilet seat (see Fig. 29(b)). Seats shall not be sprung to return to a lifted position.

4.16.4\* **Grab Bars.** Grab bars for water closets not located in stalls shall comply with 4.26 and Fig. 29. The grab bar behind the water closet shall be 36 in. (915 mm) minimum.

4.16.5\* **Flush Controls.** Flush controls shall be hand operated or automatic and shall comply with 4.27.4. Controls for flush valves shall be mounted on the wide side of toilet areas no more than 44 in. (1120 mm) above the floor.

4.16.6 **Dispensers.** Toilet paper dispensers shall be installed within reach, as shown in Fig. 29(b). Dispensers that control delivery, or that do not permit continuous paper flow, shall not be used.

4.17.6 **Grab Bars.** Grab bars complying with the length and positioning shown in Fig. 30(a), (b), (c), and (d) shall be provided. Grab bars may be mounted with any desired method as long as they have a gripping surface at the locations shown and do not obstruct the required clear floor area. Grab bars shall comply with 4.26.

## 4.19 Lavatories and Mirrors.

4.19.1 **General.** The requirements of 4.19 shall apply to lavatory fixtures, vanities, and built-in lavatories.

4.19.2 **Height and Clearances.** Lavatories shall be mounted with the rim or counter surface no higher than 34 in. (865 mm) above the finish floor. Provide a clearance of at least 29 in. (735 mm) above the finish floor to the bottom of the apron. Knee and toe clearance shall comply with Fig. 31.

EXCEPTION 1: Lavatories used primarily by children ages 6 through 12 shall be permitted to have an apron clearance and a knee clearance 24 in. (610 mm) high, minimum, provided that the rim or counter surface is no higher than 31 in. (760 mm).

EXCEPTION 2: Lavatories used primarily by children ages 5 and younger shall not be required to meet these clearances if clear floor space for a parallel approach complying with 4.2.4 is provided.

4.19.3 **Clear Floor Space.** A clear floor space 30 in. by 48 in. (760 mm by 1220 mm) complying with 4.2.4 shall be provided in front of a lavatory to allow forward approach. Such clear floor space shall adjoin or overlap an accessible route and shall extend a maximum of 19 in. (485 mm) underneath the lavatory (see Fig. 32).

4.19.4 **Exposed Pipes and Surfaces.** Hot water and drainpipes under lavatories shall be insulated or otherwise configured to protect against contact. There shall be no sharp or abrasive surfaces under lavatories.

4.19.5 **Faucets.** Faucets shall comply with 4.27.4. Lever-operated, push-type, and electronically controlled mechanisms are examples of acceptable designs. If self-closing valves are used the faucet shall remain open for at least 10 seconds.

4.19.6\* **Mirrors.** Mirrors shall be mounted with the bottom edge of the reflecting surface no higher than 40 in. (1015 mm) above the finish floor (see Fig. 31).

## 4.20 Bathtubs.

4.20.1 **General.** Accessible bathtubs shall comply with 4.20.

4.20.2 **Floor Space.** Clear floor space in front of bathtubs shall be as shown in Fig. 33.

4.20.3 **Seat.** An in-tub seat or a seat at the head end of the tub shall be provided as shown in Fig. 33 and 34. The structural strength of seats and their attachments shall comply with 4.26.3. Seats shall be mounted securely and shall not slip during use.

4.20.4 **Grab Bars.** Grab bars complying with 4.26 shall be provided as shown in Fig. 33 and 34.

4.20.5 **Controls.** Faucets and other controls complying with 4.27.4 shall be located as shown in Fig. 34.

4.20.6 **Shower Unit.** A shower spray unit with a hose at least 60 in. (1525 mm) long that can be used both as a fixed showerhead and as a hand-held shower shall be provided.

4.20.7 **Bathtub Enclosures.** If provided, enclosures for bathtubs shall not obstruct controls or transfer from wheelchairs onto bathtub seats or into tubs. Enclosures on bathtubs shall not have tracks mounted on their rims.

## 4.21 Shower Stalls.

4.21.1\* **General.** Accessible shower stalls shall comply with 4.21.

4.21.2 **Size and Clearances.** Except as specified in 9.1.2, shower stall size and clear floor space shall comply with Fig. 35(a) or (b). The shower stall in Fig. 35(a) shall be 36 in. by 36 in. (915 mm by 915 mm). Shower stalls required by 9.1.2 shall comply with Fig. 57(a) or (b). The shower stall in Fig. 35(b) will fit into the space required for a bathtub.

4.21.3 **Seat.** A seat shall be provided in shower stalls 36 in. by 36 in. (915 mm by 915 mm) and shall be as shown in Fig. 36. The seat shall be mounted 17 in. to 19 in. (430 mm to 485 mm) from the bathroom floor and shall extend the full depth of the stall. In a 36 in. by 36 in. (915 mm by 915 mm) shower stall, the seat shall be on the wall opposite the controls. Where a fixed seat is provided in a 30 in. by 60 in. minimum (760 mm by 1525 mm) shower stall, it shall be a folding type and shall be mounted on the wall

adjacent to the controls as shown in Fig. 57. The structural strength of seats and their attachments shall comply with 4.26.3.

**4.21.4 Grab Bars.** Grab bars complying with 4.26 shall be provided as shown in Fig. 37.

**4.21.5 Controls.** Faucets and other controls complying with 4.27.4 shall be located as shown in Fig. 37. In shower stalls 36 in. by 36 in. (915 mm by 915 mm), all controls, faucets, and the shower unit shall be mounted on the sidewall opposite the seat.

**4.21.6 Shower Unit.** A shower spray unit with a hose at least 60 in. (1525 mm) long that can be used both as a fixed showerhead and as a hand-held shower shall be provided.

EXCEPTION: In unmonitored facilities where vandalism is a consideration, a fixed showerhead mounted at 48 in. (1220 mm) above the shower floor may be used in lieu of a hand-held showerhead.

**4.21.7 Curbs.** If provided, curbs in shower stalls 36 in. by 36 in. (915 mm by 915 mm) shall be no higher than 1/2 in. (13 mm). Shower stalls that are 30 in. by 60 in. (760 mm by 1525 mm), minimum, shall not have curbs.

**4.21.8 Shower Enclosures.** If provided, enclosures for shower stalls shall not obstruct controls or obstruct transfer from wheelchairs onto shower seats.

## **4.22 Toilet Rooms.**

**4.22.1 Minimum Number.** Toilet facilities required to be accessible by 4.1 shall comply with 4.22. Accessible toilet rooms shall be on an accessible route.

**4.22.2 Doors.** All doors to accessible toilet rooms shall comply with 4.13. Doors shall not swing into the clear floor space required for any fixture.

**4.22.3\* Clear Floor Space.** The accessible fixtures and controls required in 4.22.4, 4.22.5, 4.22.6, and 4.22.7 shall be on an accessible route. An unobstructed turning space complying with 4.2.3 shall be provided within an accessible toilet room. The clear floor space at fixtures and controls, the accessible route, and the turning space may overlap.

**4.22.4 Water Closets.** If toilet stalls are provided, then at least one shall be a standard toilet stall complying with 4.17; where 6 or more stalls are provided, in addition to the stall complying with 4.17.3, at least one stall 36 in. (915 mm) wide with an outward swinging, self-closing door and parallel grab bars complying with Fig. 30(d) and 4.26 shall be provided. Water closets in such stalls shall comply with 4.16. If water closets are not in stalls, then at least one shall comply with 4.16.

**4.22.5 Urinals.** If urinals are provided, then at least one shall comply with 4.18.

**4.22.6 Lavatories and Mirrors.** If lavatories and mirrors are provided, then at least one of each shall comply with 4.19.

**4.22.7 Controls and Dispensers.** If controls, dispensers, receptacles, or other equipment are provided, then at least one of each shall be on an accessible route and shall comply with 4.27.

## **4.23 Bathrooms, Bathing Facilities and Shower Rooms**

**4.23.9\* Medicine Cabinets.** If medicine cabinets are provided, at least one shall be located with a usable shelf no higher than 44 in. (1120 mm) above the floor space. The floor space shall comply with 4.2.4.

## **4.24 Sinks.**

**4.24.1 General.** Sinks required to be accessible by 4.1 shall comply with 4.24.

**4.24.2 Height.** Sinks shall be mounted with the counter or rim no higher than 34 in. (865 mm) above the finish floor.

**4.24.3 Knee Clearance.** Knee clearance that is at least 27 in. (685 mm) high, 30 in. (760 mm) wide, and 19 in. (485 mm) deep shall be provided underneath sinks.

EXCEPTION 1: Sinks used primarily by children ages 6 through 12 shall be permitted to have a knee clearance 24 in. (610 mm) high, minimum, provided that the rim or counter surface is no higher than 31 in. (760 mm).

EXCEPTION 2: Sinks used primarily by children ages 5 and younger shall not be required to provide knee clearance if clear floor space for a parallel approach complying with 4.2.4 is provided

4.24.4 **Depth.** Each sink shall be a maximum of 6-1/2 in. (165 mm) deep.

4.24.5 **Clear Floor Space.** A clear floor space at least 30 in. by 48 in. (760 mm by 1220 mm) complying with 4.2.4 shall be provided in front of a sink to allow forward approach. The clear floor space shall be on an accessible route and shall extend a maximum of 19 in. (485 mm) underneath the sink (see Fig. 32).

4.24.6 **Exposed Pipes and Surfaces.** Hot water and drainpipes exposed under sinks shall be insulated or otherwise configured so as to protect against contact. There shall be no sharp or abrasive surfaces under sinks.

4.24.7 **Faucets.** Faucets shall comply with 4.27.4. Lever-operated, push-type, touch-type, or electronically controlled mechanisms are acceptable designs.

## 4.25 Storage.

4.25.1 **General.** Fixed storage facilities such as cabinets, shelves, closets, and drawers required to be accessible by 4.1 shall comply with 4.25.

4.25.2 **Clear Floor Space.** A clear floor space at least 30 in. by 48 in. (760 mm by 1220 mm) complying with 4.2.4 that allows either a forward or parallel approach by a person using a wheelchair shall be provided at accessible storage facilities.

4.25.3\* **Height.** Accessible storage spaces shall be within at least one of the reach ranges specified in 4.2.5 and 4.2.6 (see Fig. 5 and Fig 6). Clothes rods or shelves shall be a maximum of 54 in. (1370 mm) above the finish floor for a side approach. Where the distance from the wheelchair to the clothes rod or shelf exceeds 10 in. (255 mm) (as in closets without accessible doors) the height and depth to the rod or shelf shall comply with Fig. 38(a) and Fig. 38(b).

4.25.4 **Hardware.** Hardware for accessible storage facilities shall comply with 4.27.4. Touch latches and U-shaped pulls are acceptable.

## 4.26 Handrails, Grab Bars, and Tub and Shower Seats.

4.26.1\* **General.** All handrails, grab bars, and tub and shower seats required to be accessible by 4.1, 4.8, 4.9, 4.16, 4.17, 4.20 or 4.21 shall comply with 4.26.

4.26.2\* **Size and Spacing of Grab Bars and Handrails.** The diameter or width of the gripping surfaces of a handrail or grab bar shall be 1-1/4 in. to 1-1/2 in. (32 mm to 38 mm), or the shape shall provide an equivalent gripping surface. If handrails or grab bars are mounted adjacent to a wall, the space between the wall and the grab bar shall be 1-1/2 in. (38 mm) (see Fig. 39(a), (b), and (e)).

4.26.3 **Structural Strength.** The structural strength of grab bars, tub and shower seats, fasteners, and mounting devices shall meet the following specification:

(1) Bending stress in a grab bar or seat induced by the maximum bending moment from the application of 250 lbf (1112N) shall be less than the allowable stress for the material of the grab bar or seat.

(2) Shear stress induced in a grab bar or seat by the application of 250 lbf (1112N) shall be less than the allowable shear stress for the material of the grab bar or seat. If the connection between the grab bar or seat and its mounting bracket or other support is considered to be fully restrained, then direct and torsional shear stresses shall be totaled for the combined shear stress, which shall not exceed the allowable shear stress.

(3) Shear force induced in a fastener or mounting device from the application of 250 lbf (1112N) shall be less than the allowable lateral load of either the fastener or mounting device or the supporting structure, whichever is the smaller allowable load.

(4) Tensile force induced in a fastener by a direct tension force of 250 lbf (1112N) plus the maximum moment from the application of 250 lbf (1112N) shall be less than the allowable withdrawal load between the fastener and the supporting structure.

(5) Grab bars shall not rotate within their fittings.

4.26.4 **Eliminating Hazards.** A handrail or grab bar and any wall or other surface adjacent to it shall be free of any sharp or abrasive elements. Edges shall have a minimum radius of 1/8 in. (3.2 mm).

## 4.27 Controls and Operating Mechanisms.

4.27.1 **General.** Controls and operating mechanisms required to be accessible by 4.1 shall comply with 4.27.

4.27.2 **Clear Floor Space.** Clear floor space complying with 4.2.4 that allows a forward or a parallel approach by a person using a wheelchair shall be provided at controls, dispensers, receptacles, and other operable equipment.

4.27.3\* **Height.** The highest operable part of controls, dispensers, receptacles, and other operable equipment shall be placed within at least one of the reach ranges specified in 4.2.5 and 4.2.6. Electrical and communications system receptacles on walls shall be mounted no less than 15 in. (380 mm) above the floor.

EXCEPTION: These requirements do not apply where the use of special equipment dictates otherwise or where electrical and communications systems receptacles are not normally intended for use by building occupants.

4.27.4 **Operation.** Controls and operating mechanisms shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate controls shall be no greater than 5 lbf (22.2 N).

## 4.28 Alarms.

4.28.1 **General.** Alarm systems required to be accessible by 4.1 shall comply with 4.28. At a minimum, visual signal appliances shall be provided in buildings and facilities in each of the following areas: restrooms and any other general usage areas (e.g., meeting rooms), hallways, lobbies, and any other area for common use.

4.28.2\* **Audible Alarms.** If provided, audible emergency alarms shall produce a sound that exceeds the prevailing equivalent sound level in the room or space by at least 15 dbA or exceeds any maximum sound level with a duration of 60 seconds by 5 dbA, whichever is louder. Sound levels for alarm signals shall not exceed 120 dbA.

4.28.3\* **Visual Alarms.** Visual alarm signal appliances shall be integrated into the building or facility alarm system. If single station audible alarms are provided then single station visual alarm signals shall be provided. Visual alarm signals shall have the following minimum photometric and location features:

(1) The lamp shall be a xenon strobe type or equivalent.

(2) The color shall be clear or nominal white (i.e., unfiltered or clear filtered white light).

(3) The maximum pulse duration shall be two-tenths of one second (0.2 sec) with a maximum duty cycle of 40 percent. The pulse duration is defined as the time interval between initial and final points of 10 percent of maximum signal.

- (4) The intensity shall be a minimum of 75 candela.
- (5) The flash rate shall be a minimum of 1 Hz and a maximum of 3 Hz.
- (6) The appliance shall be placed 80 in. (2030 mm) above the highest floor level within the space or 6 in. (152 mm) below the ceiling, whichever is lower.

## 4.29 Detectable Warnings.

4.29.1 **General.** Detectable warnings required by 4.1 and 4.7 shall comply with 4.29.

4.29.2\* **Detectable Warnings on Walking Surfaces.** Detectable warnings shall consist of raised truncated domes with a diameter of nominal 0.9 in. (23 mm), a height of nominal 0.2 in. (5 mm) and a center-to-center spacing of nominal 2.35 in. (60 mm) and shall contrast visually with adjoining surfaces, either light-on-dark, or dark-on-light.

The material used to provide contrast shall be an integral part of the walking surface. Detectable warnings used on interior surfaces shall differ from adjoining walking surfaces in resiliency or sound-on-cane contact.

4.29.3 **Detectable Warnings on Doors To Hazardous Areas.** (Reserved).

4.29.4 **Detectable Warnings at Stairs.** (Reserved).

4.29.5 **Detectable Warnings at Hazardous Vehicular Areas.** [*Provision suspended until July 26, 2001*] If a walk crosses or adjoins a vehicular way, and the walking surfaces are not separated by curbs, railings, or other elements between the pedestrian areas and vehicular areas, the boundary between the areas shall be defined by a continuous detectable warning which is 36 in. (915 mm) wide, complying with 4.29.2.

## 4.30 Signage.

4.30.1\* **General.** Signage required to be accessible by 4.1 shall comply with the applicable provisions of 4.30.

4.30.2\* **Character Proportion.** Letters and numbers on signs shall have a width-to-height ratio between 3:5 and 1:1 and a stroke-width-to-height ratio between 1:5 and 1:10.

4.30.3 **Character Height.** Characters and numbers on signs shall be sized according to the viewing distance from which they are to be read. The minimum height is measured using an upper case X. Lower case characters are permitted.

### Height Above Finished Floor

### Minimum Character Height

Suspended or Projected Overhead in compliance with 4.4.2

3 in. (75 mm) minimum

4.30.4 **Raised and Brailled Characters and Pictorial Symbol Signs (Pictograms).** Letters and numerals shall be raised 1/32 in. (0.79 mm) minimum, upper case, sans serif or simple serif type and shall be accompanied with Grade 2 Braille. Raised characters shall be at least 5/8 in. (16 mm) high, but no higher than 2 in. (50 mm). Pictograms shall be accompanied by the equivalent verbal description placed directly below the pictogram. The border dimension of the pictogram shall be 6 in. (152 mm) minimum in height.

4.30.5\* **Finish and Contrast.** The characters and background of signs shall be eggshell, matte, or other non-glare finish. Characters and symbols shall contrast with their background -- either light characters on a dark background or dark characters on a light background.

4.30.6 **Mounting Location and Height.** Where permanent identification is provided for rooms and spaces, signs shall be installed on the wall adjacent to the latch side of the door. Where there is no wall space to the latch side of the door, including at double leaf doors, signs shall be placed on the nearest adjacent wall. Mounting height shall be 60 in. (1525 mm) above the finish floor to the centerline of the sign. Mounting location for such signage shall be so that a person may approach within 3 in. (76 mm) of signage without encountering protruding objects or standing within the swing of a door.



## Definitions

### Access Aisle.

An accessible pedestrian space between elements, such as parking spaces, seating, and desks, that provides clearances appropriate for use of the elements.

### Accessible.

Describes a site, building, facility, or portion thereof that complies with these guidelines.

### Accessible Element.

An element specified by these guidelines (for example, telephone, controls, and the like).

### Accessible Route.

A continuous, unobstructed path connecting all accessible elements and spaces of a building or facility. Interior accessible routes may include corridors, floors, ramps, elevators, lifts, and clear floor space at fixtures. Exterior accessible routes may include parking access aisles, curb ramps, crosswalks at vehicular ways, walks, ramps, and lifts.

### Accessible Space.

Space that complies with these guidelines.

### Administrative Authority.

A governmental agency that adopts or enforces regulations and guidelines for the design, construction, or alteration of buildings and facilities.

### Building.

Any structure used and intended for supporting or sheltering any use or occupancy.

### Circulation Path.

An exterior or interior way of passage from one place to another for pedestrians, including, but not limited to, walks, hallways, courtyards, stairways, and stair landings.

### Clear.

Unobstructed.

### Clear Floor Space.

The minimum unobstructed floor or ground space required to accommodate a single, stationary wheelchair and occupant.

### Cross Slope.

The slope that is perpendicular to the direction of travel (see running slope).

### Curb Ramp.

A short ramp cutting through a curb or built up to it.

#### Detectable Warning.

A standardized surface feature built in or applied to walking surfaces or other elements to warn visually impaired people of hazards on a circulation path.

#### Dwelling Unit.

A single unit which provides a kitchen or food preparation area, in addition to rooms and spaces for living, bathing, sleeping, and the like. Dwelling units include a single family home or a townhouse used as a transient group home; an apartment building used as a shelter; guestrooms in a hotel that provide sleeping accommodations and food preparation areas; and other similar facilities used on a transient basis. For purposes of these guidelines, use of the term "Dwelling Unit" does not imply the unit is used as a residence.

#### Egress, Means of.

A continuous and unobstructed way of exit travel from any point in a building or facility to a public way. A means of egress comprises vertical and horizontal travel and may include intervening room spaces, doorways, hallways, corridors, passageways, balconies, ramps, stairs, enclosures, lobbies, horizontal exits, courts and yards. An accessible means of egress is one that complies with these guidelines and does not include stairs, steps, or escalators. Areas of rescue assistance or evacuation elevators may be included as part of accessible means of egress.

#### Element.

An architectural or mechanical component of a building, facility, space, or site, e.g., telephone, curb ramp, door, drinking fountain, seating, or water closet.

#### Entrance.

Any access point to a building or portion of a building or facility used for the purpose of entering. An entrance includes the approach walk, the vertical access leading to the entrance platform, the entrance platform itself, vestibules if provided, the entry door(s) or gate(s), and the hardware of the entry door(s) or gate(s).

#### Facility.

All or any portion of buildings, structures, site improvements, complexes, equipment, roads, walks, passageways, parking lots, or other real or personal property located on a site.

#### Power-assisted Door.

A door used for human passage with a mechanism that helps to open the door, or relieves the opening resistance of a door, upon the activation of a switch or a continued force applied to the door itself.

#### Ramp.

A walking surface which has a running slope greater than 1:20.

#### Running Slope.

The slope that is parallel to the direction of travel (see cross slope).

Signage.

Displayed verbal, symbolic, tactile, and pictorial information.

Sleeping Accommodations.

Rooms in which people sleep; for example, dormitory and hotel or motel guest rooms or suites.

Space.

A definable area, e.g., room, toilet room, hall, assembly area, entrance, storage room, alcove, courtyard, or lobby.

Tactile.

Describes an object that can be perceived using the sense of touch.

TDD (Telecommunication Devices for the Deaf).

See text telephone.

Walk.

An exterior pathway with a prepared surface intended for pedestrian use, including general pedestrian areas such as plazas and courts.

## Appendix - Figures

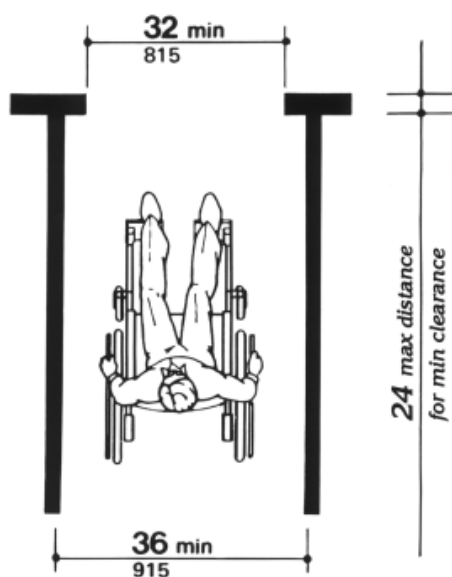


Figure 1

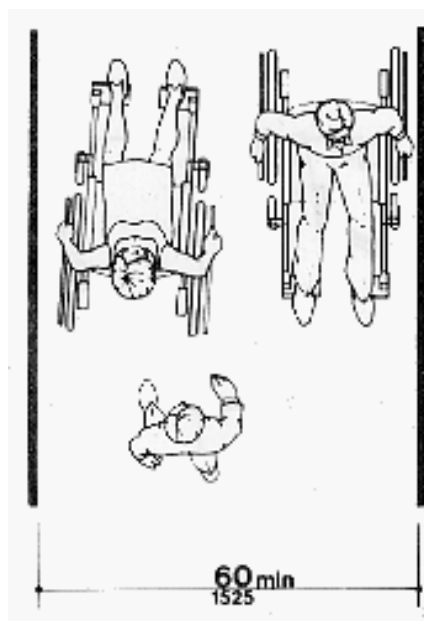
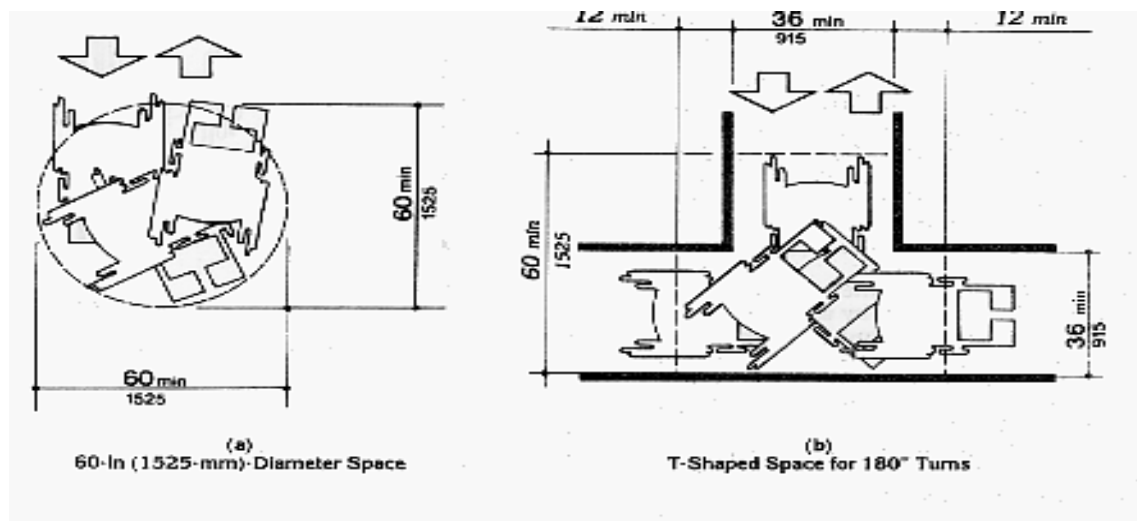
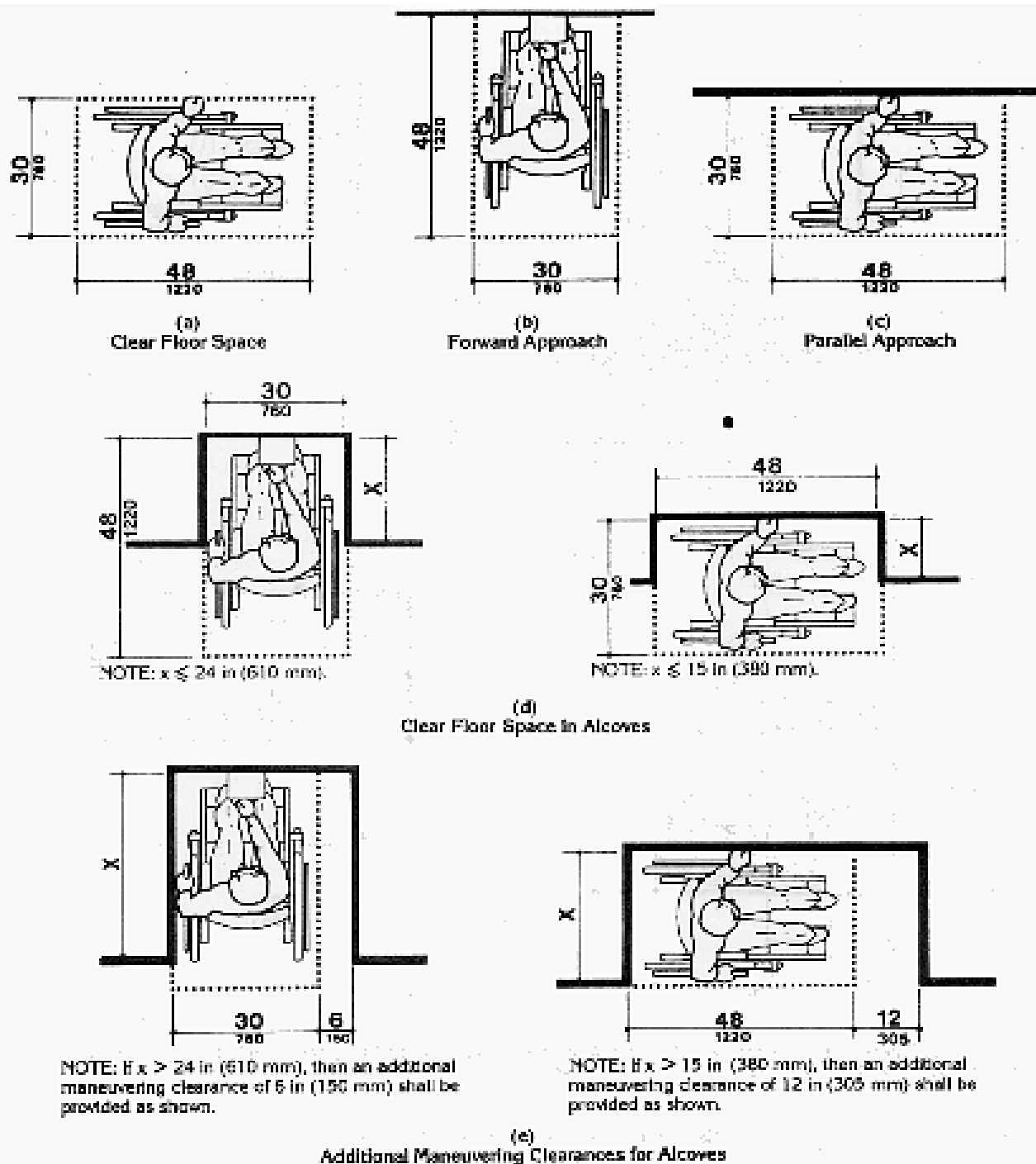


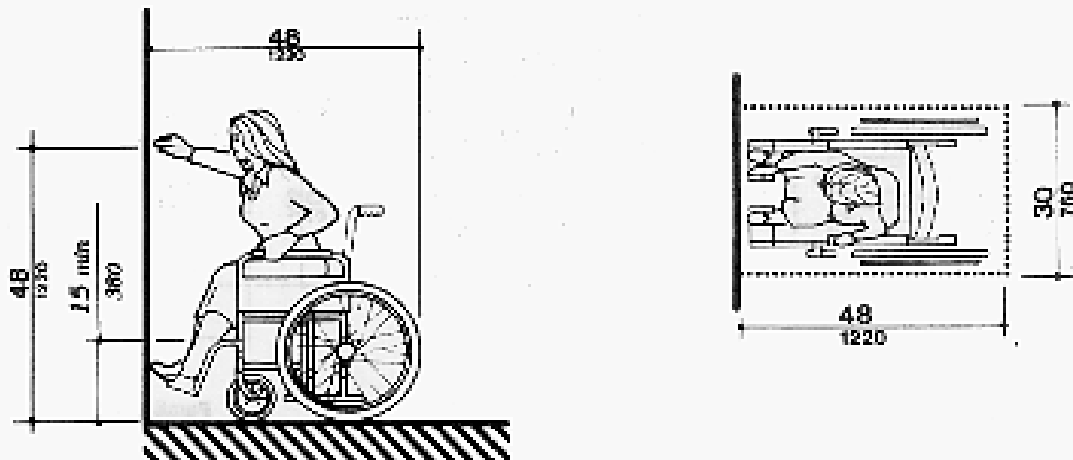
Figure 2



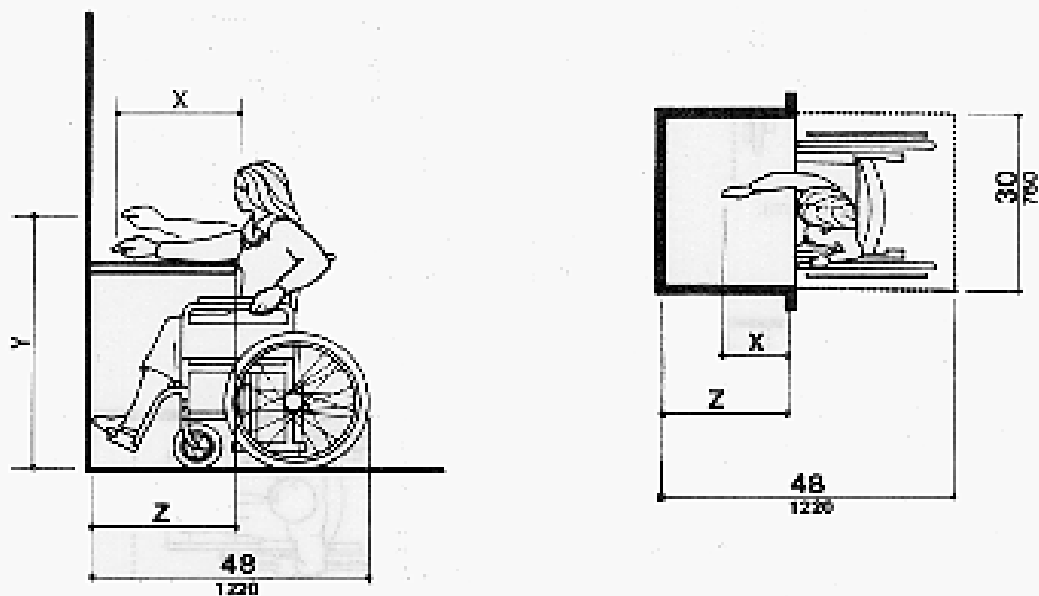
Figures 3



Figures 4



(a)  
High Forward Reach Limit



NOTE: x shall be  $\leq 25$  in (635 mm); z shall be  $\geq x$ . When x < 20 in (510 mm), then y shall be 48 in (1220 mm) maximum. When x is 20 to 25 in (510 to 635 mm), then y shall be 44 in (1120 mm) maximum.

(b)  
Maximum Forward Reach over an Obstruction

Figures 5

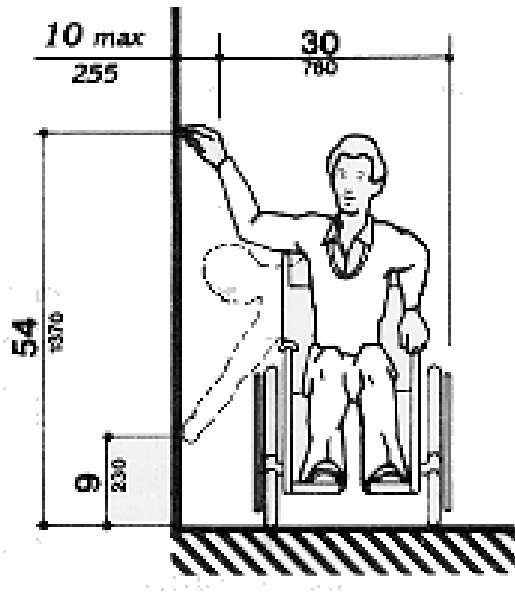


Figure 6b

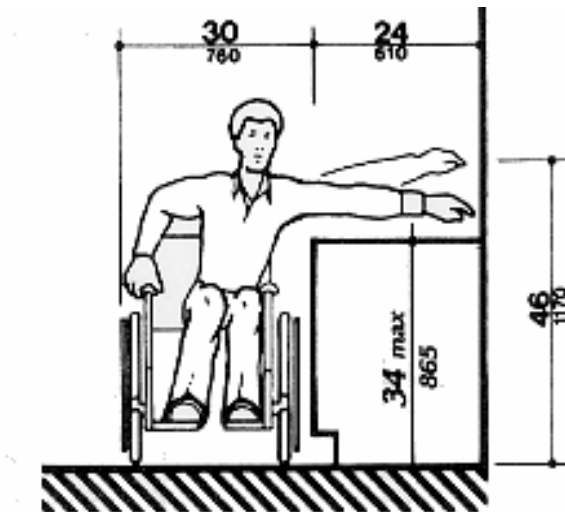
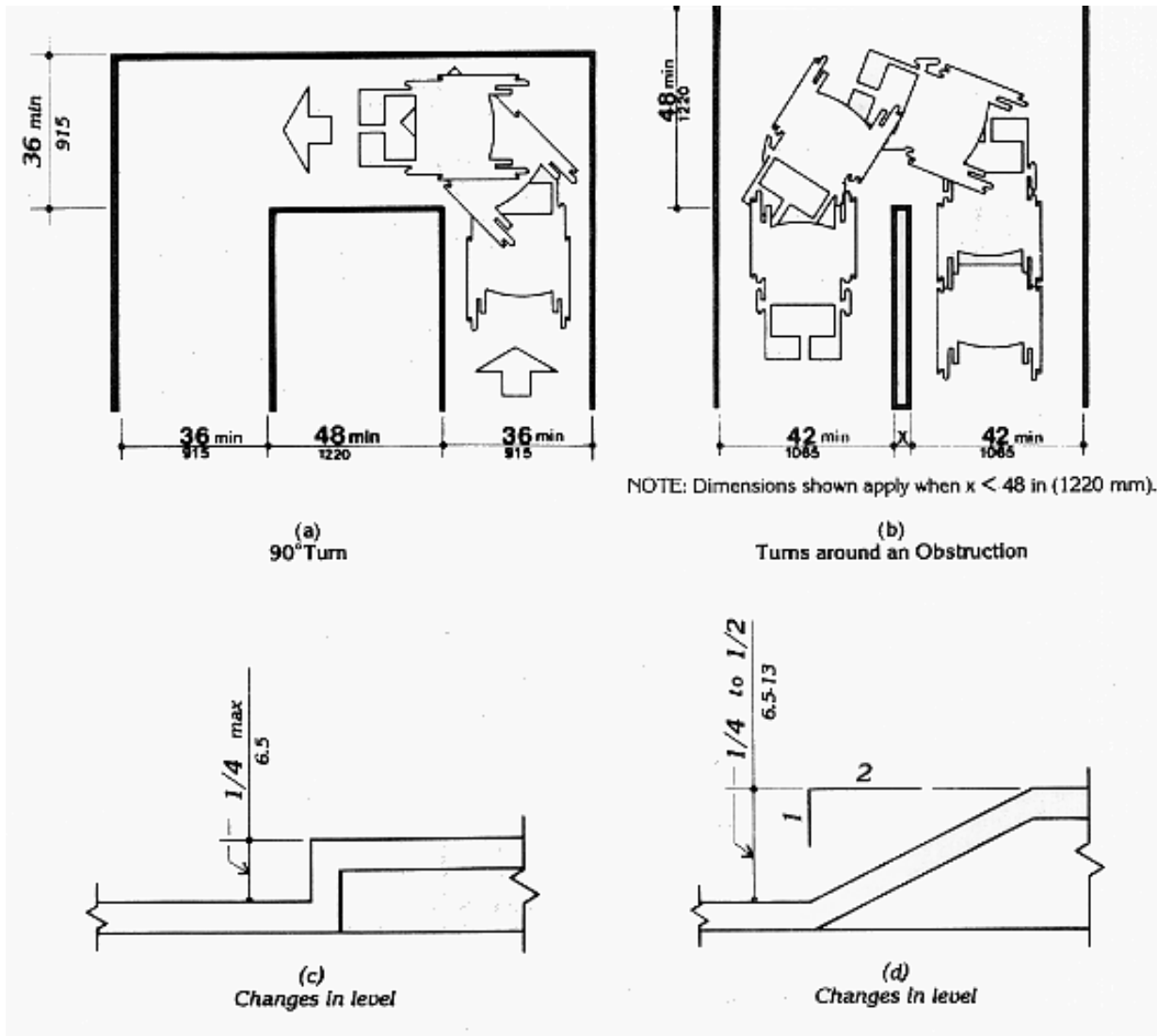
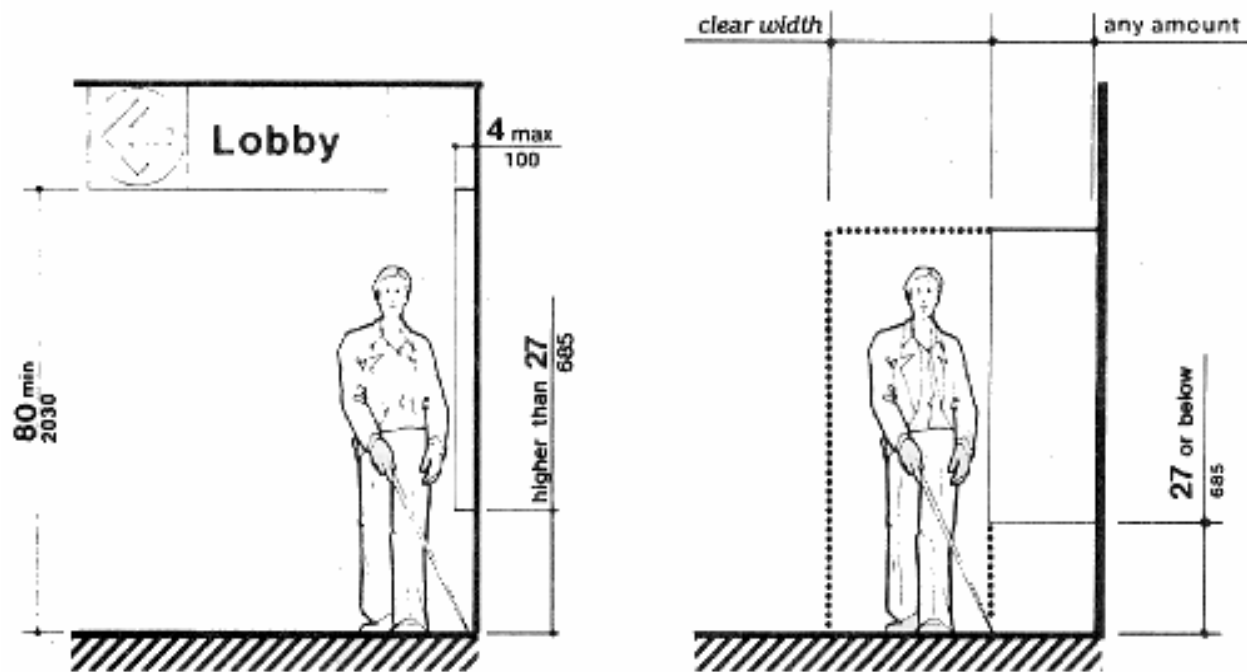


Figure 6c



Figures 7





Figures 8a

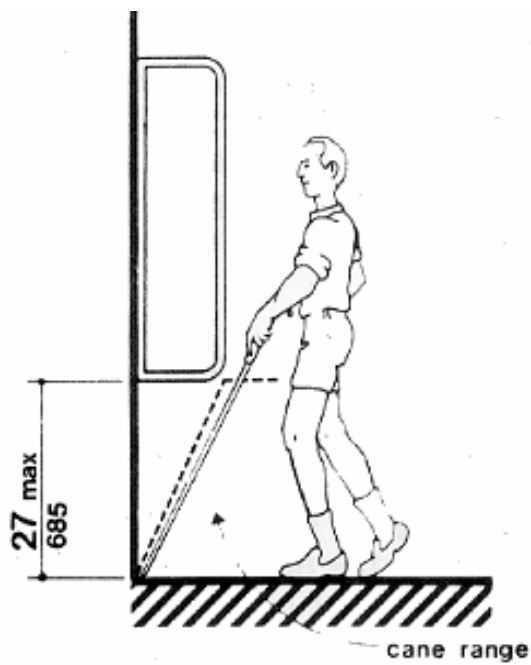
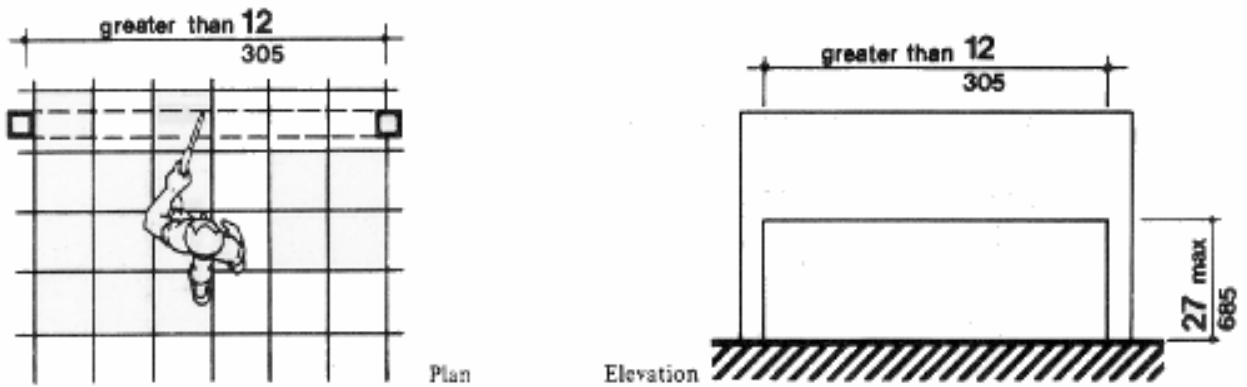


Figure 8b



Figures 8c

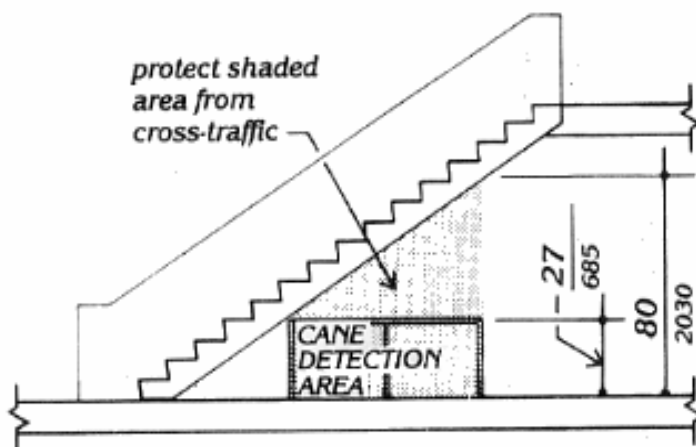
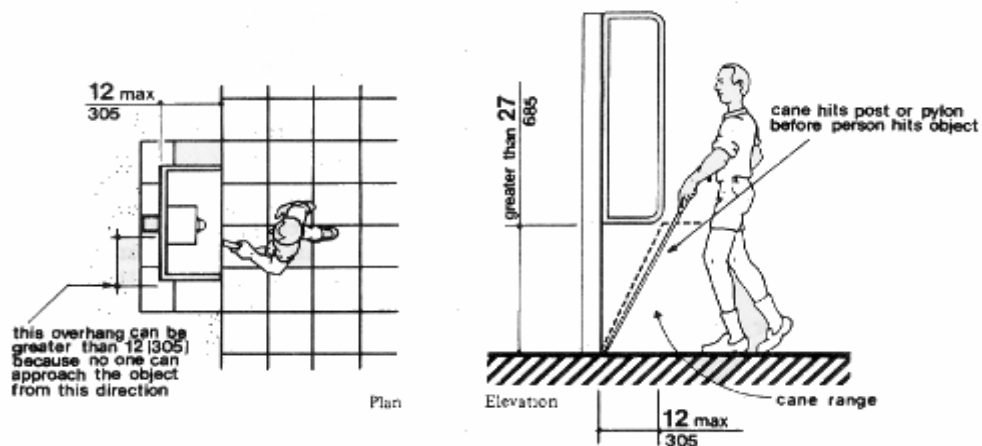


Figure 8c-1



Figures 8d

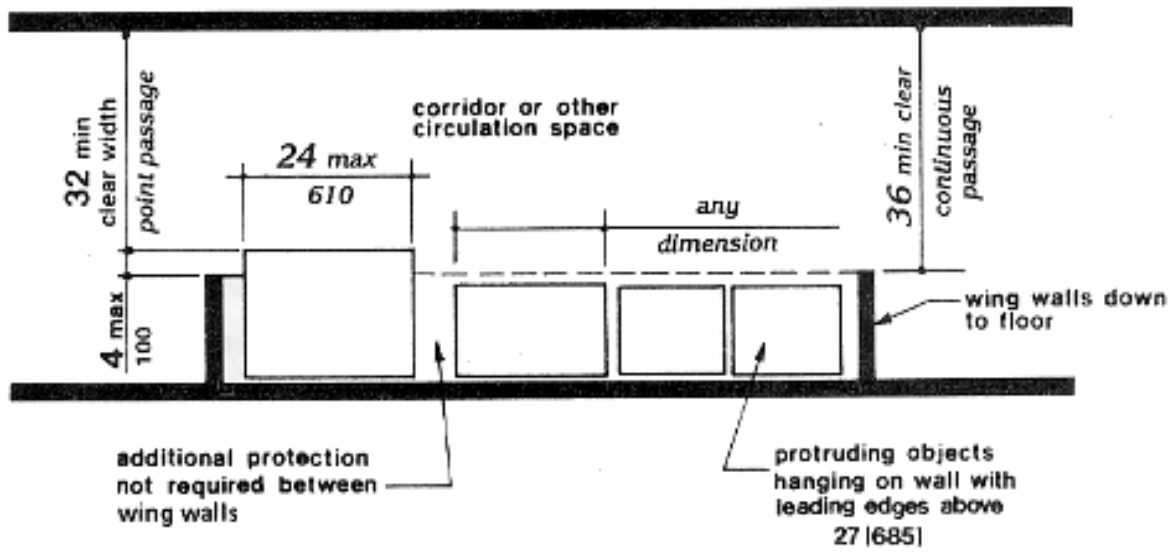


Figure 8e

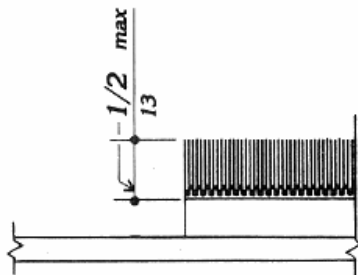


Figure 8f

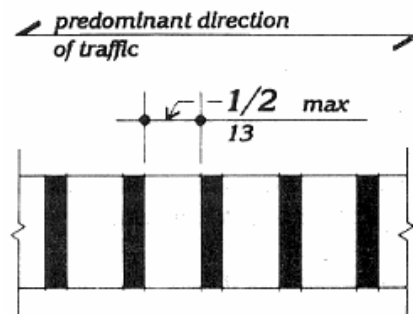
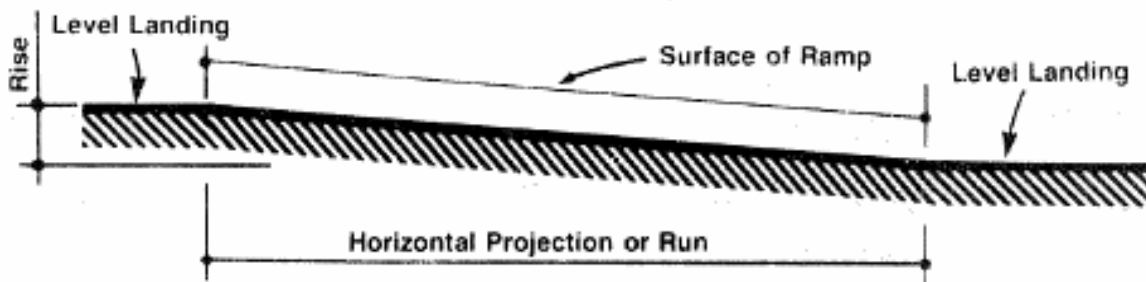
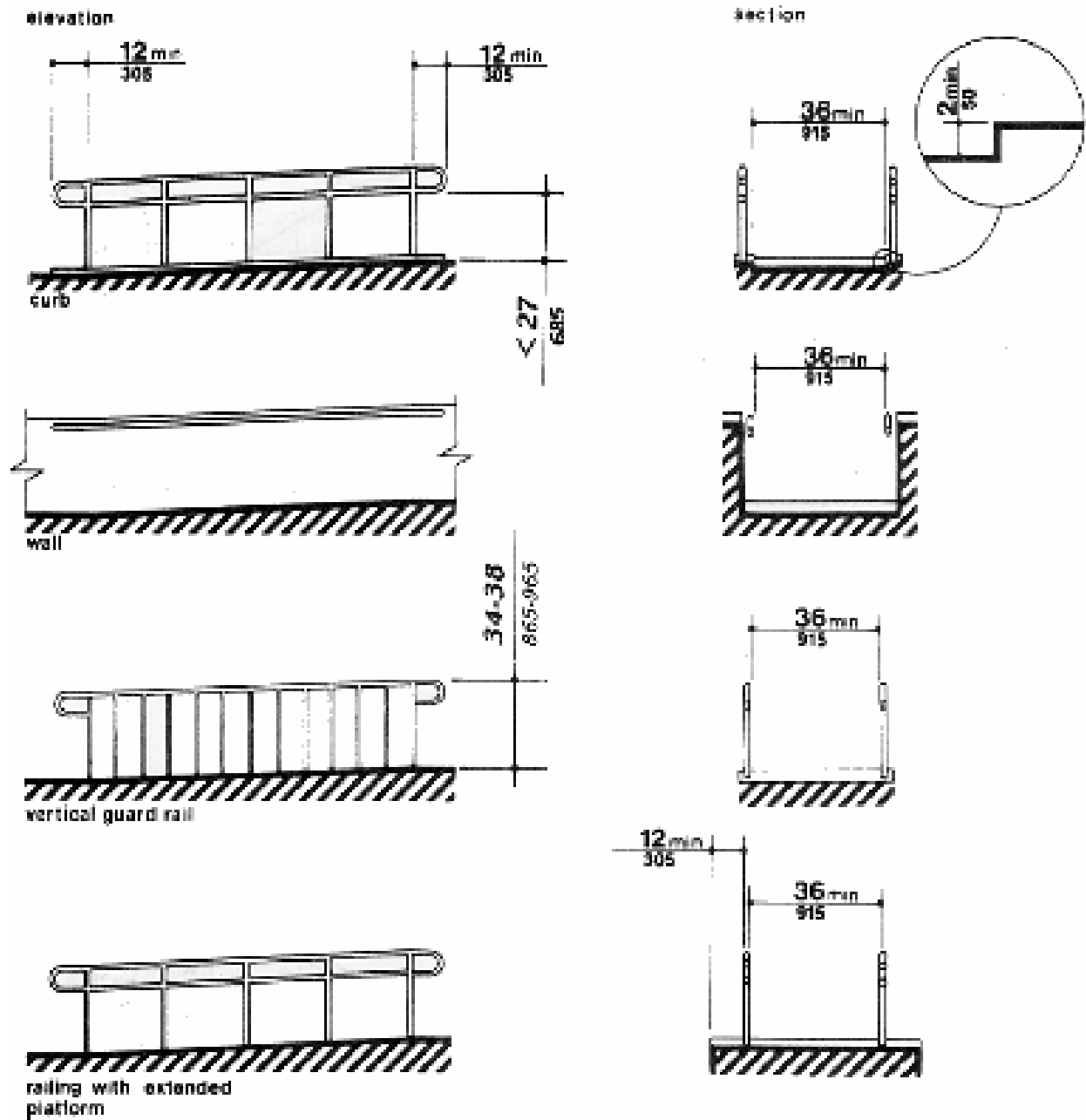


Figure 8g



Slope	Maximum Rise		Maximum Horizontal Projection	
	in	mm	ft	m
<i>1:12 to &lt; 1:16</i>	30	760	30	9
<i>1:16 to &lt; 1:20</i>	30	760	40	12

**Figure 16**



Figures 17

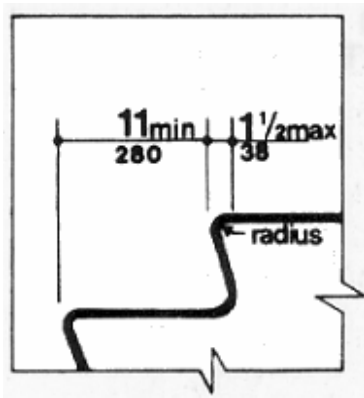


Figure 18

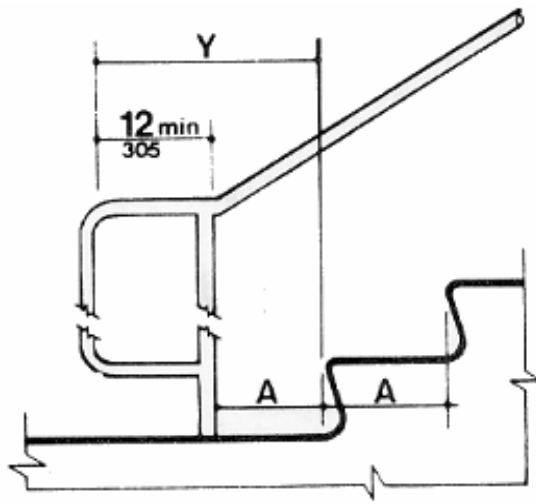


Figure 19c

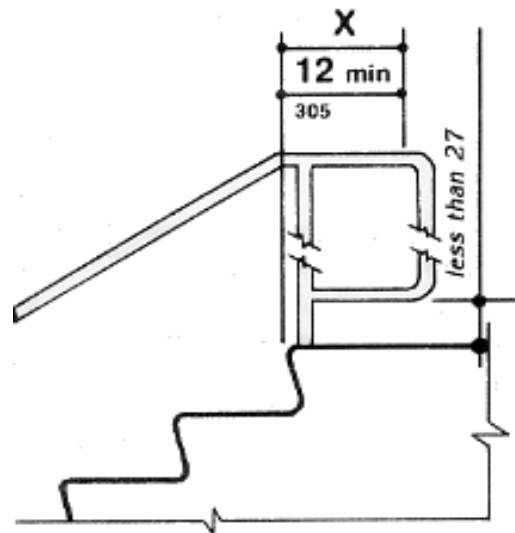


Figure 19d

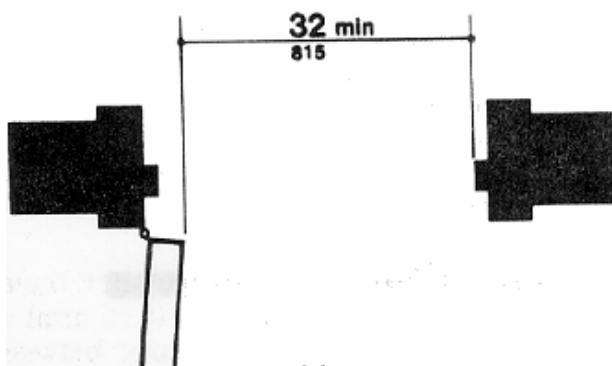


Figure 24a

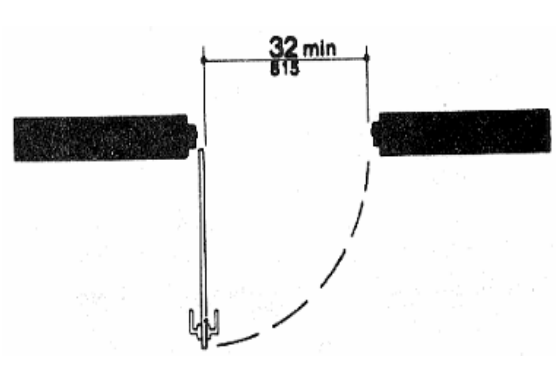


Figure 24b

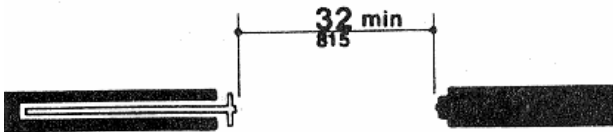


Figure 24c

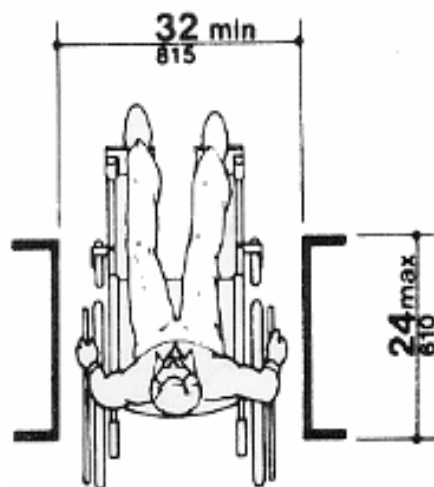


Figure 24d

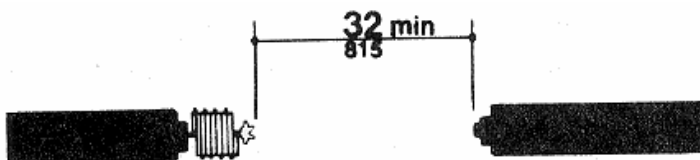
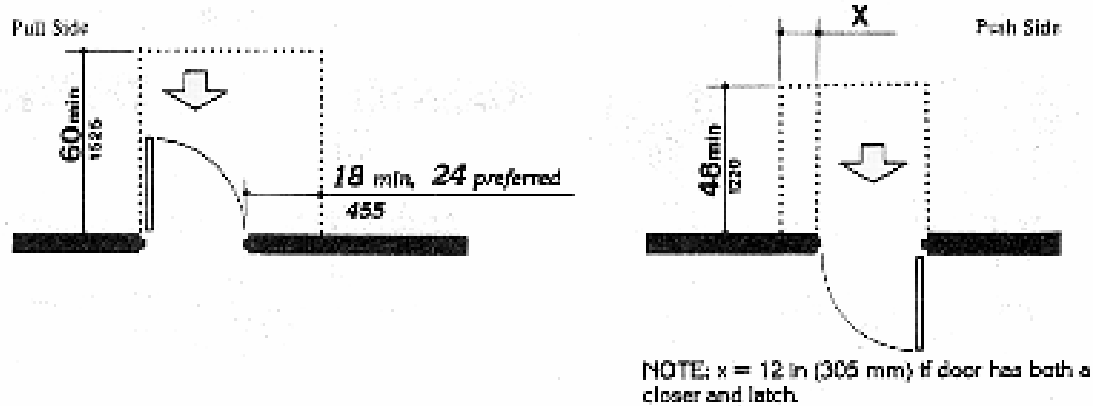
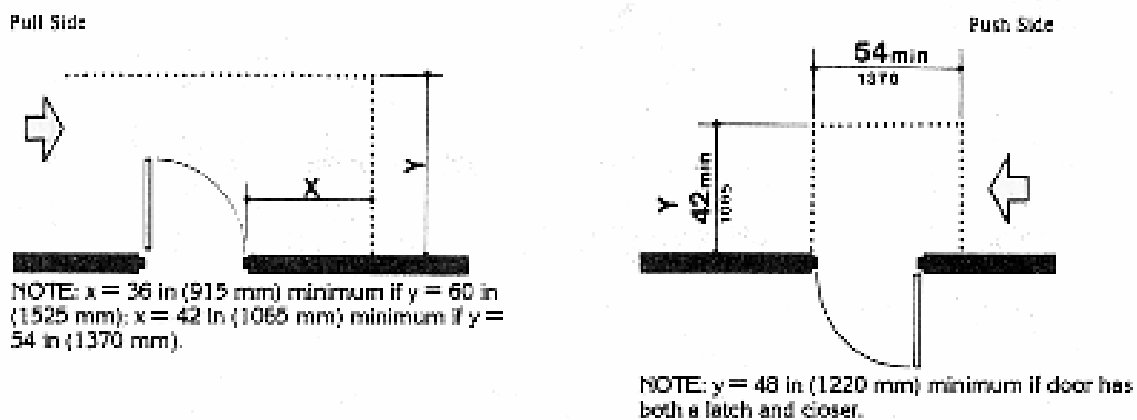


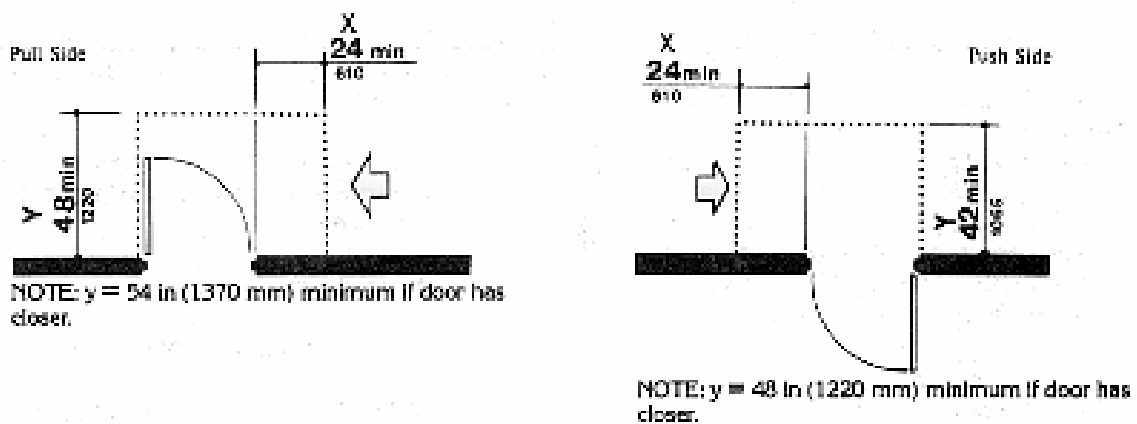
Figure 24e



(a)  
Front Approaches — Swinging Doors



(b)  
Hinge Side Approaches — Swinging Doors

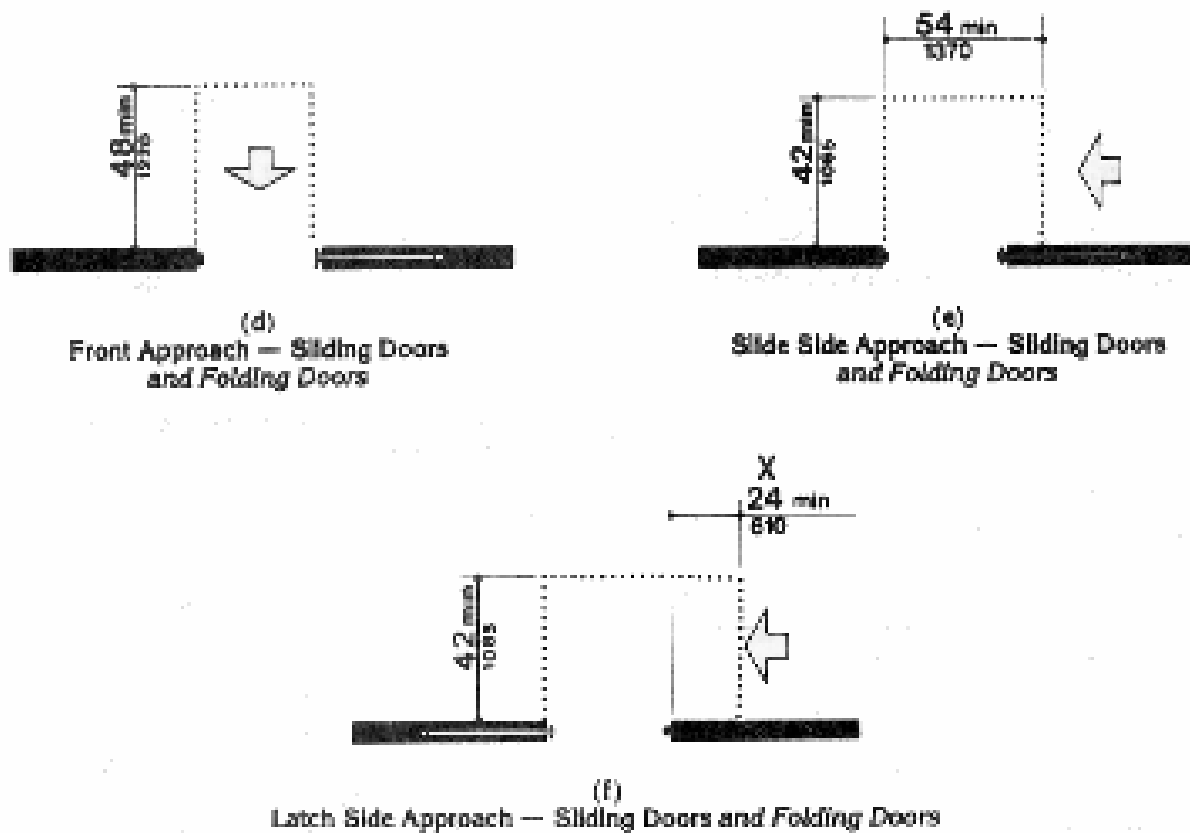


(c)  
Latch Side Approaches — Swinging Doors

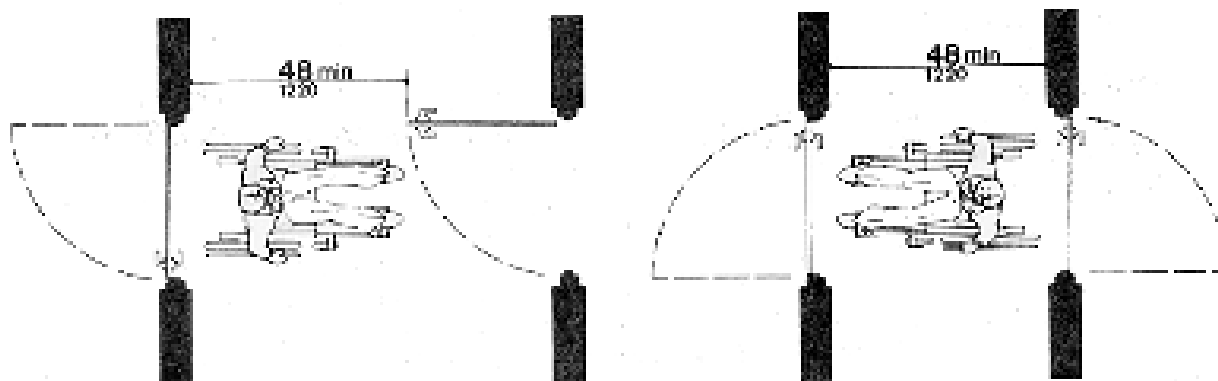
NOTE: All doors in alcoves shall comply with the clearances for front approaches.

Figures 25

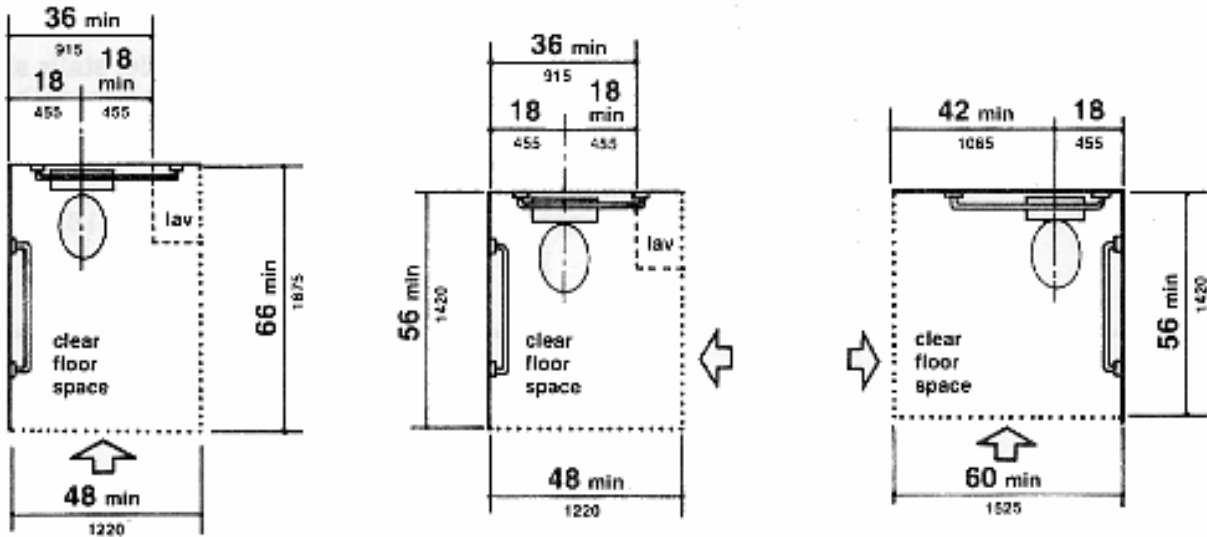




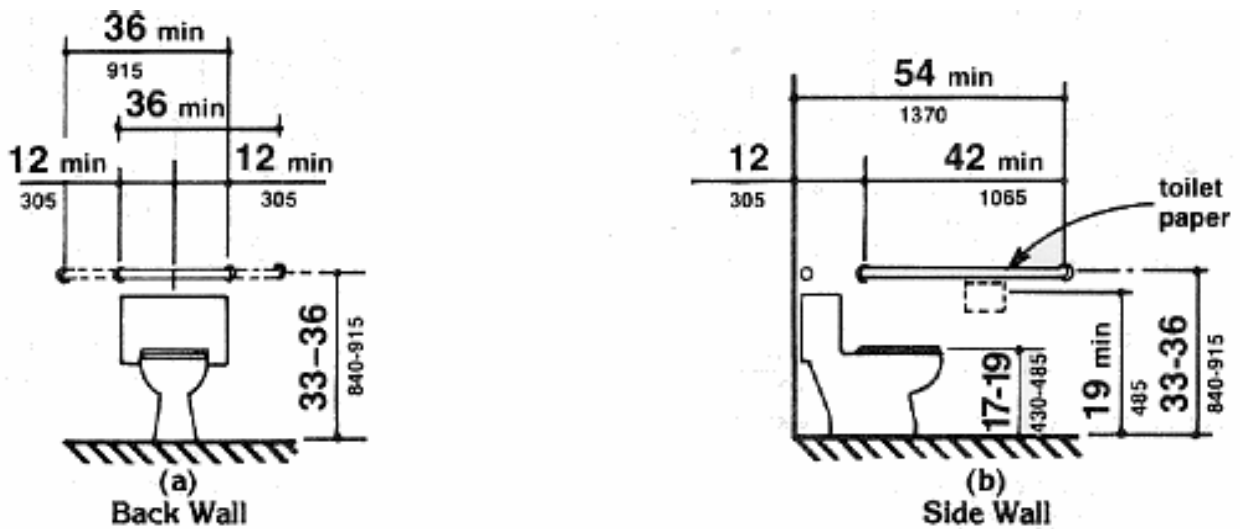
Figures 25 (continued)



Figures 26



Figures 28



Figures 29

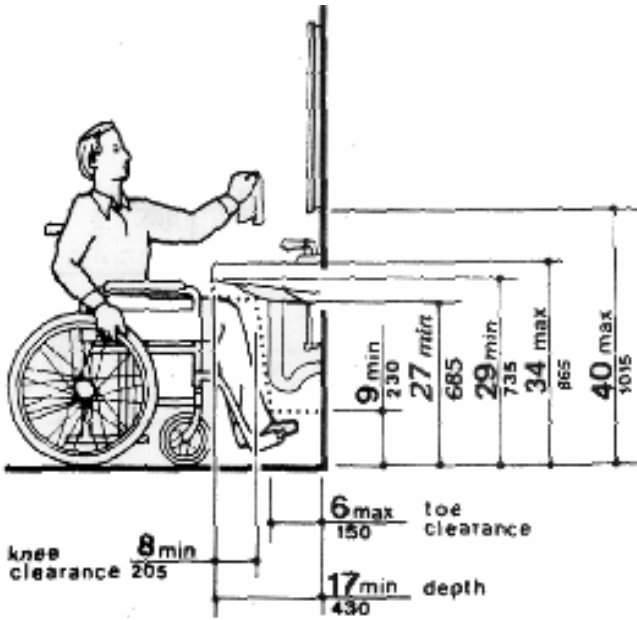


Figure 31

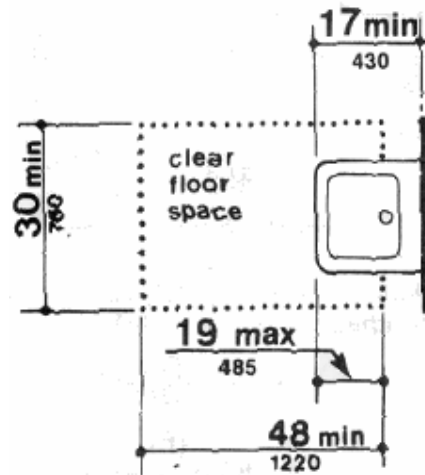
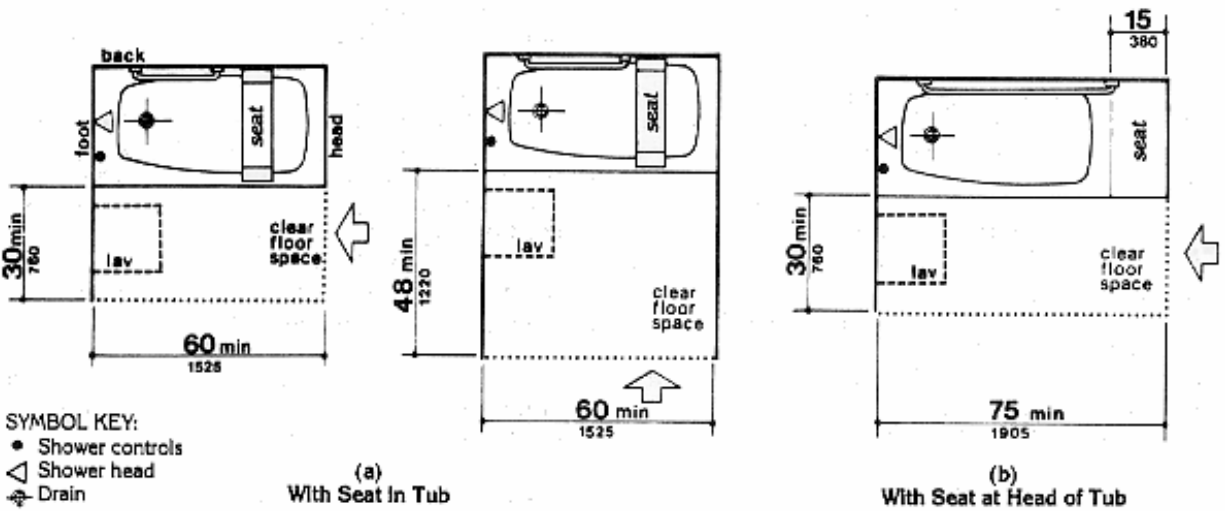
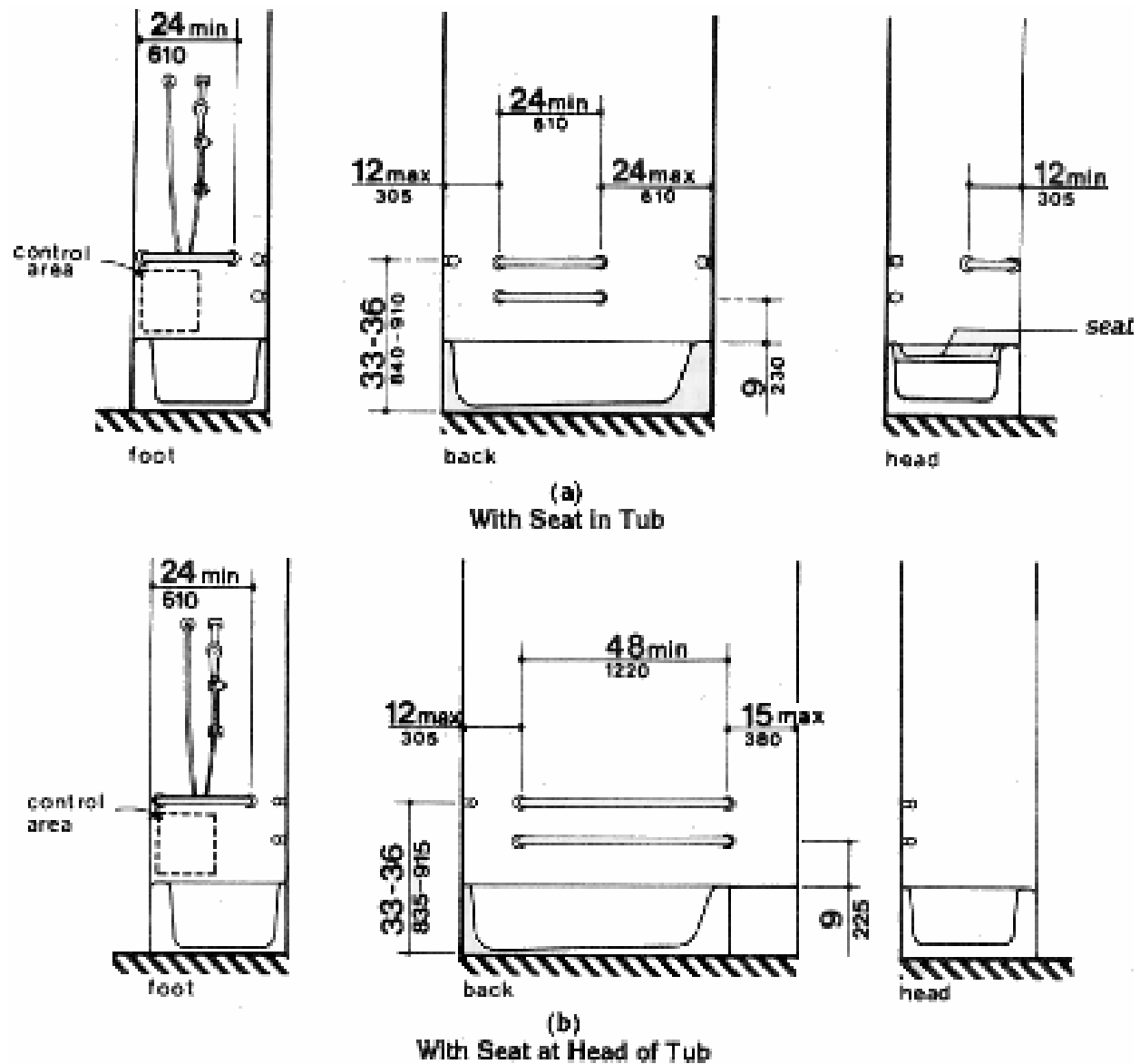


Figure 32



Figures 33



Figures 34

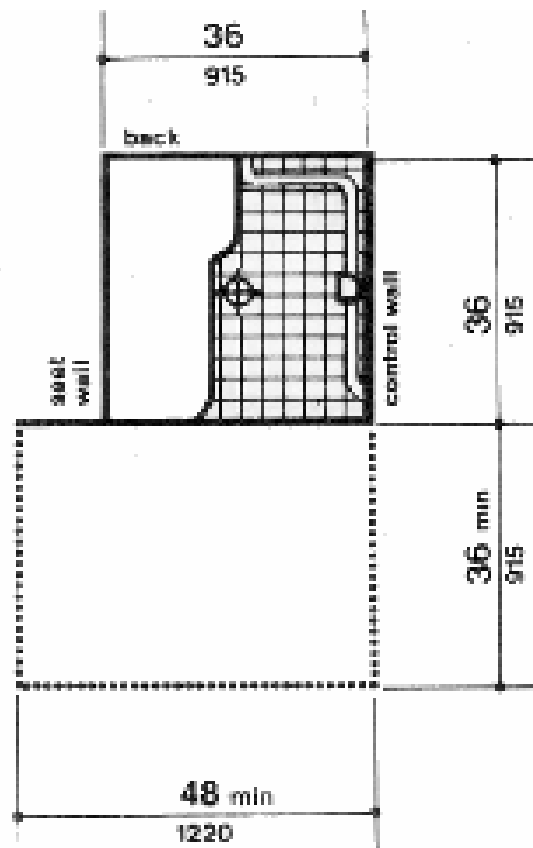


Figure 35a

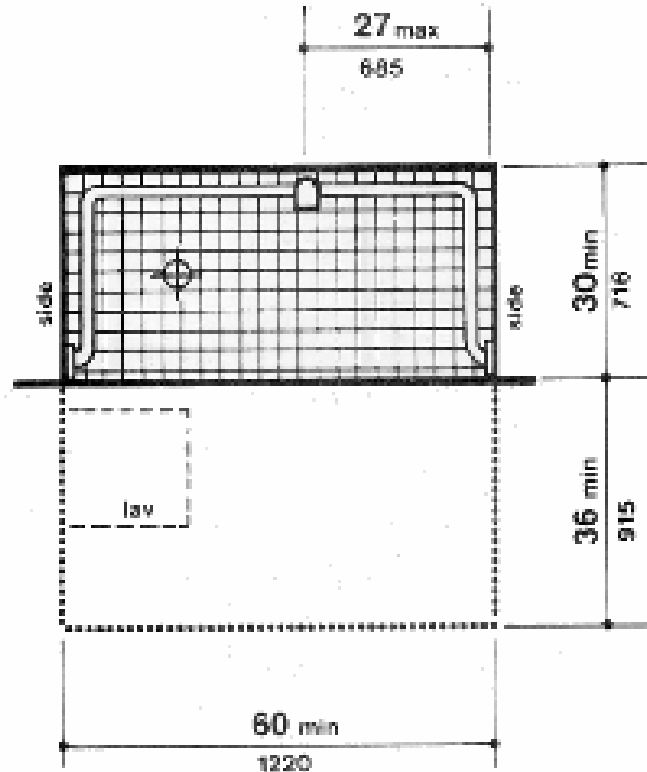


Figure 35b

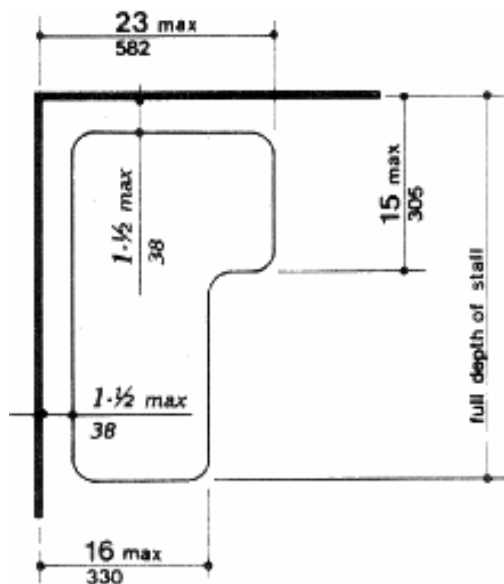
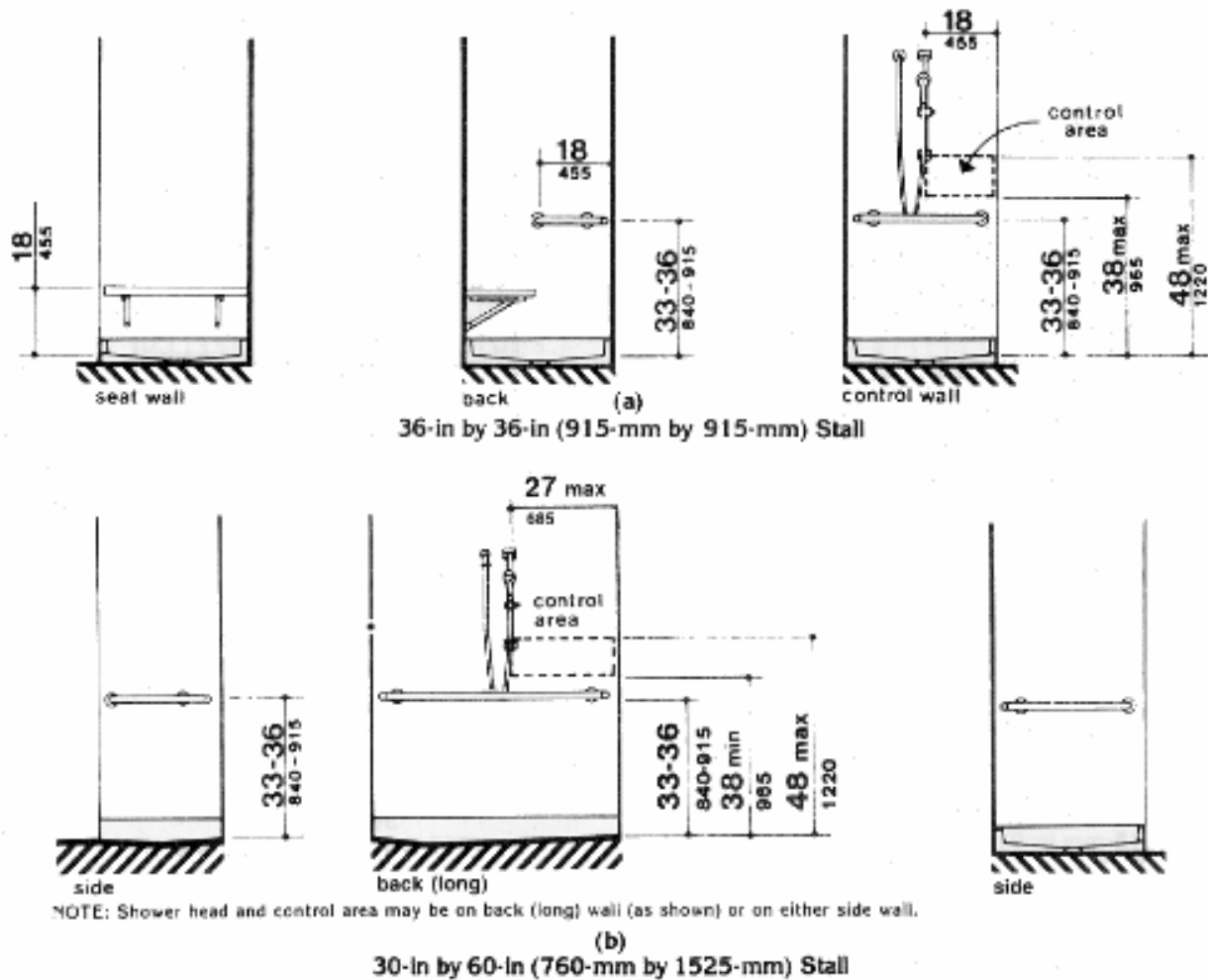


Figure 36



Figures 37

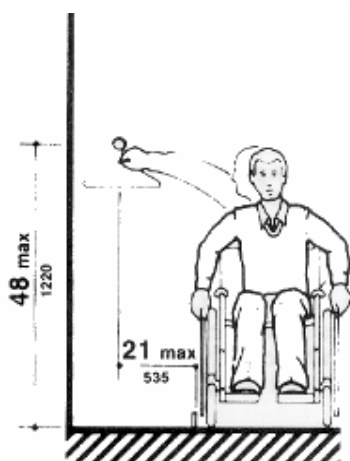


Figure 38a

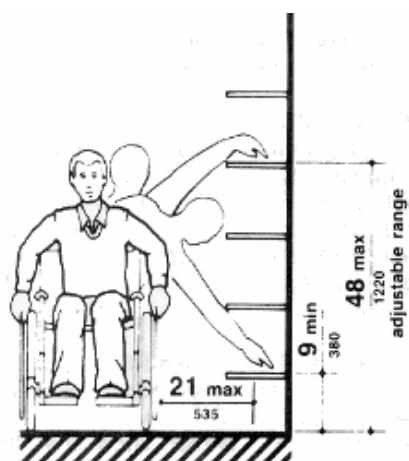


Figure 38b

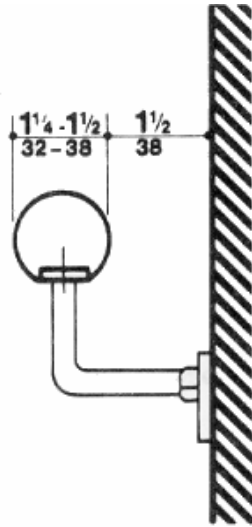


Figure 39a

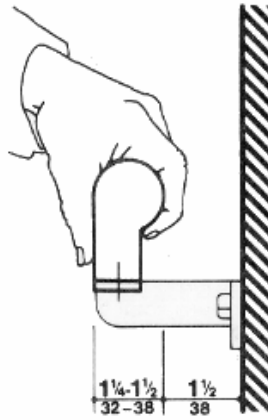


Figure 39b

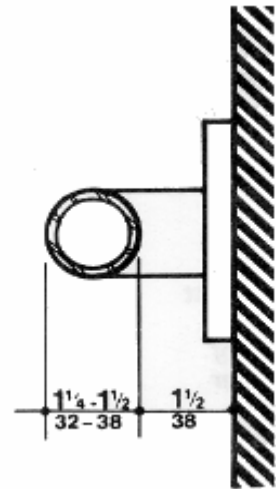


Figure 39c